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Marine Fish and Invertebrate Atlas: Summarizing Geographic Distribution and Population Indices in the Scotian Shelf and Bay of Fundy (1970-2020)

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MARINE FISH AND INVERTEBRATE ATLAS: SUMMARIZING GEOGRAPHIC DISTRIBUTION, POPULATION INDICES AND ENVIRONMENTAL PREFERENCES IN THE SCOTIAN SHELF AND BAY OF FUNDY (1970-2020)

by

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CONTENTS

ABSTRACT ix

RÉSUMÉ x

1 Introduction 1

2 Methods 2

2.1 Survey Description . . . 2

2.2 Sampling Design . . . 3

2.3 Taxonomic Levels . . . 4

2.4 Analyses . . . 13

2.4.1 Geographic distribution of catches . . . 13

2.4.2 Abundance and biomass indices . . . 13

2.4.3 Distribution indices . . . 13

2.4.4 Length frequencies . . . 13

2.4.5 Length-weight relationship and condition factor . . . 14

2.4.6 Depth, temperature and salinity distribution of catches . . . 14

2.4.7 Density-dependent habitat selection . . . 14

3 Results 15

3.1 Description of Figures . . . 15

3.1.1 Type A . . . 15

3.1.2 Type B . . . 15

3.1.3 Type C. . . . 15

3.1.4 Type D. . . . 16

3.1.5 Type E. . . . 16

3.1.6 Type F. . . . 16

3.2 Summary of successful tows by year and stratum . . . 16

4 Discussion **20**

4.1 Diversity of approaches used for mapping fish and invertebrates in the Scotian Shelf bioregion 20

4.2 Interpreting spatial results for marine spatial planning purposes 22

5 Acknowledgements **23**

6 References **24**

7 Appendix **28**

7.1 Atlantic cod (Morue franche) - species code 10 (category LF) 29

7.2 Haddock (Aiglefin) - species code 11 (category LF) 32

7.3 White hake (Merluche blanche) - species code 12 (category LF) 35

7.4 Red hake (Merluche écureuil) - species code 13 (category LF) 38

7.5 Silver hake (Merlu argenté) - species code 14 (category LF) 41

7.6 Pollock (Goberge) - species code 16 (category LF) 44

7.7 Atlantic redfishes (Sébastes de l'Atlantique) - species code 23 (category LF) 47

7.8 Atlantic halibut (Flétan de l'Atlantique) - species code 30 (category LF) 50

7.9 American plaice (Plie canadienne) - species code 40 (category LF) 53

7.10 Witch flounder (Plie grise) - species code 41 (category LF) 56

7.11 Yellowtail flounder (Limande à queue jaune) - species code 42 (category LF) 59

7.12 Winter flounder (Limande-plie rouge) - species code 43 (category LF) 62

7.13 Atlantic wolffish (Loup atlantique) - species code 50 (category LF) 65

7.14 Atlantic herring (Hareng de l'Atlantique) - species code 60 (category LF) 68

7.15 Longhorn sculpin (Chaboisseau à dix-huit épines) - species code 300 (category LF) 71

7.16 Moustache sculpin (Faux-trigle armé) - species code 304 (category LF) 74

7.17 Sea raven (Hémitriptère atlantique) - species code 320 (category LF) 77

7.18 Alligatorfish (Poisson-alligator atlantique) - species code 340 (category LF) 80

7.19 Monkfish (Baudroie d'Amérique) - species code 400 (category LF) 83

7.20 Ocean pout (Loquette d'Amérique) - species code 640 (category LF) 86
7.21 Thorny skate (Raie épineuse) - species code 201 (category LF) 89
7.22 Smooth skate (Raie lisse) - species code 202 (category LF) 92
7.23 Winter skate (Raie tachetée) - species code 204 (category LF) 95
7.24 Picked dogfish (Aiguillat commun) - species code 220 (category LF) 98
7.25 Northern shortfin squid (Encornet rouge nordique) - species code 4511 (category LF) 101
7.26 Atlantic hagfish (Myxine du nord) - species code 241 (category LI) 104
7.27 Cusk (Brosme) - species code 15 (category LI) 105
7.28 Greenland halibut (Flétan noir) - species code 31 (category LI) 106
7.29 Gulf Stream flounder (Plie du Gulf Stream) - species code 44 (category LI) 107
7.30 American shad (Alose savoureuse) - species code 61 (category LI) 108
7.31 Alewife (Gaspareau) - species code 62 (category LI) 109
7.32 Capelin (Capelan) - species code 64 (category LI) 110
7.33 Atlantic mackerel (Maquereau commun) - species code 70 (category LI) 111
7.34 Longfin hake (Merluche à longues nageoires) - species code 112 (category LI) . . . 112
7.35 Fourbeard rockling (Motelle à quatre barbillons) - species code 114 (category LI) . . 113
7.36 Blackbelly rosefish (Sébaste chèvre) - species code 123 (category LI) 114
7.37 Greater argentine (Grande argentine) - species code 160 (category LI) 115
7.38 Arctic hookear sculpin (Hameçon neigeux) - species code 306 (category LI) 116
7.39 Atlantic poacher (Agone atlantique) - species code 350 (category LI) 117
7.40 Marlin-spike grenadier (Grenadier du Grand Banc) - species code 410 (category LI) 118
7.41 Lumpfish (Lompe) - species code 501 (category LI) 119
7.42 Atlantic spiny lumpsucker (Petite poule de mer atlantique) - species code 502 (category LI) 120
7.43 Sand lance (Lançon) - species code 610 (category LI) 121
7.44 Snakeblenny (Lompénie-serpent) - species code 622 (category LI) 122
7.45 Daubed shanny (Lompénie tachetée) - species code 623 (category LI) 123

7.46 Vahl's eelpout (Lycode à carreaux) - species code 647 (category LI) 124
7.47 Atlantic butterfish (Stromaté fossette) - species code 701 (category LI) 125
7.48 Atlantic hookear sculpin (Hameçon atlantique) - species code 880 (category LI) . . . 126
7.49 Barndoor skate (Grande raie) - species code 200 (category LI) 127
7.50 Little skate (Raie hérisson) - species code 203 (category LI) 128
7.51 Northern prawn (Crevette nordique) - species code 2211 (category SF) 129
7.52 Jonah crab (Tourteau jona) - species code 2511 (category SF) 130
7.53 Atlantic rock crab (Tourteau poïnclos) - species code 2513 (category SF) 131
7.54 Arctic lyre crab (Crabe Hyas coarctatus) - species code 2521 (category SF) 132
7.55 Atlantic king crab (Crabe épineux du nord) - species code 2523 (category SF) 133
7.56 Queen crab (Crabe des neiges) - species code 2526 (category SF) 134
7.57 Great spider crab (Crabe lyre araignée) - species code 2527 (category SF) 135
7.58 American lobster (Homard américain) - species code 2550 (category SF) 136
7.59 Sea lamprey (Lamproie marine) - species code 240 (category LR) 137
7.60 Atlantic tomcod (Poulamon atlantique) - species code 17 (category LR) 138
7.61 Offshore silver hake (Merlu argenté du large) - species code 19 (category LR) . . . 139
7.62 Spotted wolffish (Loup tacheté) - species code 51 (category LR) 140
7.63 Northern wolffish (Loup à tête large) - species code 52 (category LR) 141
7.64 Rainbow smelt (Éperlan arc-en-ciel) - species code 63 (category LR) 142
7.65 Cunner (Tanche-tautogue) - species code 122 (category LR) 143
7.66 Fourspot flounder (Cardeau à quatre ocelles) - species code 142 (category LR) . . . 144
7.67 Windowpane flounder (Turbot de sable) - species code 143 (category LR) 145
7.68 Longnose greeneye (Oeil-vert à long nez) - species code 149 (category LR) 146
7.69 Lanternfishes (Poissons-lanternes) - species code 150 (category LR) 147
7.70 Shortnose greeneye (Éperlan du large) - species code 156 (category LR) 148
7.71 Silvery lightfish (Brossé améthyste) - species code 158 (category LR) 149
7.72 Boa dragonfish (Dragon-boa) - species code 159 (category LR) 150

7.73 Shorthorn sculpin (Chaboisseau à épines courtes) - species code 301 (category LR) 151
7.74 Grubby (Chaboisseau bronzé) - species code 303 (category LR) 152
7.75 Polar sculpin (Cotte polaire) - species code 307 (category LR) 153
7.76 Spatulate sculpin (Icèle spatulée) - species code 314 (category LR) 154
7.77 Arctic alligatorfish (Poisson-alligator arctique) - species code 341 (category LR) . . . 155
7.78 Alligatorfishes (Poissons-alligator) - species code 351 (category LR) 156
7.79 Roughnose grenadier (Grenadier-scie) - species code 412 (category LR) 157
7.80 Roundnose grenadier (Grenadier de roche) - species code 414 (category LR) 158
7.81 Atlantic seasnail (Limace atlantique) - species code 503 (category LR) 159
7.82 Gelatinous snailfish (Limace gélatineuse) - species code 505 (category LR) 160
7.83 Variegated snailfish (Limace marbée) - species code 512 (category LR) 161
7.84 Sea tadpole (Petite limace de mer) - species code 520 (category LR) 162
7.85 Wolf eelpout (Lycode à tête longue) - species code 603 (category LR) 163
7.86 Slender snipe eel (Avocette ruban) - species code 604 (category LR) 164
7.87 Newfoundland eelpout (Lycode du Labrador) - species code 619 (category LR) . . . 165
7.88 Newfoundland eelpout (Lycode du Labrador) - species code 620 (category LR) . . . 166
7.89 Rock gunnel (Sigouine de roche) - species code 621 (category LR) 167
7.90 Radiated shanny (Ulvaire deux-lignes) - species code 625 (category LR) 168
7.91 Fourline snakeblenny (Quatre-lignes atlantique) - species code 626 (category LR) . 169
7.92 Wrymouth (Terrassier tacheté) - species code 630 (category LR) 170
7.93 Spotfin dragonet (Dragonnet tacheté) - species code 637 (category LR) 171
7.94 Arctic eelpout (Lycode arctique) - species code 641 (category LR) 172
7.95 Atlantic soft pout (Molasse atlantique) - species code 646 (category LR) 173
7.96 Silvery John dory (Saint Pierre argenté) - species code 704 (category LR) 174
7.97 White barracudina (Lussion blanc) - species code 712 (category LR) 175
7.98 Atlantic saury (Balaou atlantique) - species code 720 (category LR) 176
7.99 Hatchetfishes (Haches d'argent) - species code 741 (category LR) 177

159 7.100 Atlantic batfish (Malthe atlantique) - species code 742 (category LR) 178
160 7.101 Spottedfin tonguefish (Langue fil noir) - species code 816 (category LR) 179
161 7.102 Black dogfish (Aiguillat noir) - species code 221 (category LR) 180
162 7.103 Longfin inshore squid (Calmar totam) - species code 4512 (category LR) 181
163 7.104 Red deepsea crab (Crabe rouge) - species code 2532 (category SR) 182

164 **INDEX** **183**

ABSTRACT

Ricard, D., Emberley, J., Gomez, C. and Regnier-McKellar, C. 2021. Marine Fish and Invertebrate Atlas: Summarizing Geographic Distribution, Population Indices and Environmental Preferences in the Scotian Shelf and Bay of Fundy (1970-2020). Can. Tech. Rep. Fish. Aquat. Sci. nnn: x + 188 p.

The summer groundfish research vessel survey on the Scotian Shelf and in the Bay of Fundy started in 1970 and was designed to measure the distribution and abundance of major commercial fish species. Over time, additional information on non-commercial species was collected, and allowed considerable insight into ecosystem function and structure, as documented in many primary publications whose analyses used the survey data. The same groundfish survey database has also been used to produce species status reports, atlases of species distribution and remains an essential source of information for stock assessments in the Maritimes Region of Fisheries and Oceans Canada. This report builds on previous work and former atlases by updating a comprehensive suite of indices to assess population status and environmental preferences of 104 species. For each species, trends in geographic distribution and biomass or abundance were plotted. The spatial extent of distribution was plotted over time to gauge how the area occupied has changed. The relationship between abundance or biomass and spatial extent reflected whether the species distribution expands when abundance or biomass increases. Length frequencies over time depicted any changes in mean size. The plots of condition over time revealed whether individual fish are fatter or thinner than their long term mean. Depth, temperature and salinity preferences were estimated to gauge the range of suitable environmental parameters for each species. Finally, for each stratum, the slope describing how local density varies with regional abundance was estimated.

RÉSUMÉ

Ricard, D., Emberley, J., Gomez, C. and Regnier-McKellar, C. 2021. Marine Fish and Invertebrate Atlas: Summarizing Geographic Distribution, Population Indices and Environmental Preferences in the Scotian Shelf and Bay of Fundy (1970-2020). Can. Tech. Rep. Fish. Aquat. Sci. nnn: x + 188 p.

Le relevé estival par navires de recherche sur le poisson de fond sur le plateau néo-écossais et dans la baie de Fundy a débuté en 1970 et visait à mesurer la répartition et l'abondance des principales espèces de poissons commerciales. Au fil du temps, des informations supplémentaires sur les espèces non commerciales ont été recueillies et ont permis de mieux comprendre la fonction et la structure de l'écosystème, comme le montrent de nombreuses publications primaires dont les analyses ont utilisé les données des relevés. La même base de données sur les relevés du poisson de fond a également été utilisée pour produire des rapports sur la situation des espèces, des atlas de la répartition des espèces et demeure une source essentielle d'information pour les évaluations des stocks dans la région des Maritimes de Pêches et Océans Canada. Ce rapport s'appuie sur des travaux antérieurs et d'anciens atlas en mettant à jour une série complète d'indices pour évaluer l'état de la population et les préférences environnementales de 104 espèces. Pour chaque espèce, les tendances de la répartition géographique et de la biomasse ou de l'abondance ont été tracées. L'étendue spatiale de la distribution a été tracée au fil du temps pour évaluer comment la zone occupée a changé. La relation entre l'abondance ou la biomasse et l'étendue spatiale indique si la répartition des espèces augmente lorsque l'abondance ou la biomasse augmente. Les fréquences de longueur au fil du temps représentaient tout changement dans la taille moyenne. Les graphiques de l'état au fil du temps ont révélé si les poissons individuels sont plus gros ou plus minces que leur moyenne à long terme. Les préférences en matière de profondeur, de température et de salinité ont été estimées pour évaluer la gamme de paramètres environnementaux appropriés pour chaque espèce. Enfin, pour chaque strate, la pente décrivant comment la densité locale varie avec l'abondance régionale a été estimée.

1 Introduction

The summer (July-August) groundfish research vessel survey on the Scotian Shelf and in the Bay of Fundy was started in 1970 by Fisheries and Oceans Canada Maritimes Region. The survey was originally designed to measure the distribution and abundance of major commercial fish species. Over time, information on non-commercial species was also collected. The groundfish survey database storing the information collected during the annual survey provides the main source of fisheries-independent information for marine species in the region. This information is routinely used to support stock assessments, to produce species status reports and has been previously used to publish atlases of species distribution.

The current document is an update of an earlier report (Ricard and Shackell 2013) that built on former atlases by updating a comprehensive suite of derived indices for 104 species to assess population status and environmental preferences. The information collected during the survey is stored in a relational database management system archived at Fisheries and Oceans Canada Maritimes Region which contains detailed information about the sampling locations and the associated catch. Tow-level survey data is also publicly available from the Ocean Biogeographic Information System (DFO 2016) and (DFO 2021). The present atlas follows on the work done by Fisheries and Oceans colleagues from the northern Gulf of St. Lawrence (Bourdages and Ouellet 2012), southern Gulf of St. Lawrence (Benoît et al. 2003) and on earlier work in the Scotian Shelf (Simon and Comeau 1994; Horsman and Shackell 2009).

To facilitate updates and foster collaboration on the analyses of the survey data, the computer code necessary to extract the data, to perform the analyses presented herein, and to reproduce and update the current document is made available in a git repository (Ricard and Gomez 2021).

The survey area covers three major Northwest Atlantic Fisheries Organization (NAFO) zones that divide the shelf into the colder east 4V and 4W (strata 440-466) and warmer west 4X (strata 470-495). Temporal trends are plotted by NAFO regions for several species. For each species, trends in geographic distribution and biomass or abundance are plotted. Some caution is required in interpreting the results obtained for several taxa due to low sample size as explained later in the text. The spatial extent of distribution is plotted over time to gauge how the area occupied has changed. The relationship between biomass and spatial extent reflects whether the species distribution expands when biomass increases. For each strata, the slope describing how local density varies with regional abundance was estimated (Myers and Stokes 1989). These slopes were then plotted against a habitat suitability index to identify important strata for each species. Then, length frequencies over time depicted any changes in mean size. The plots of condition over time revealed whether individual fish are fatter or thinner than their long term mean. Finally, depth, temperature and salinity preferences were estimated to gauge the range of environmental parameters (Perry and Smith 1994). A full ecological interpretation of trends is beyond the scope of this report. Other documents stemming from peer-reviewed scientific processes under the auspices of the Canadian Science Advisory Secretariat (CSAS) provide further descriptions of spatio-temporal trends in different indicators and put the information collected during the summer groundfish research vessel survey in a more focused context (see for example Clark and Emberley (2011)).

2 Methods

2.1 Survey Description

The survey is conducted annually in July-August and covers the Scotian Shelf and the Bay of Fundy (Figure 1). It normally involves two separate two-week trips on board an offshore fisheries vessel from the Canadian Coast Guard.

A number of changes in fishing gear type and vessels used occurred since the onset of sampling activities (Clark and Emberley 2011).

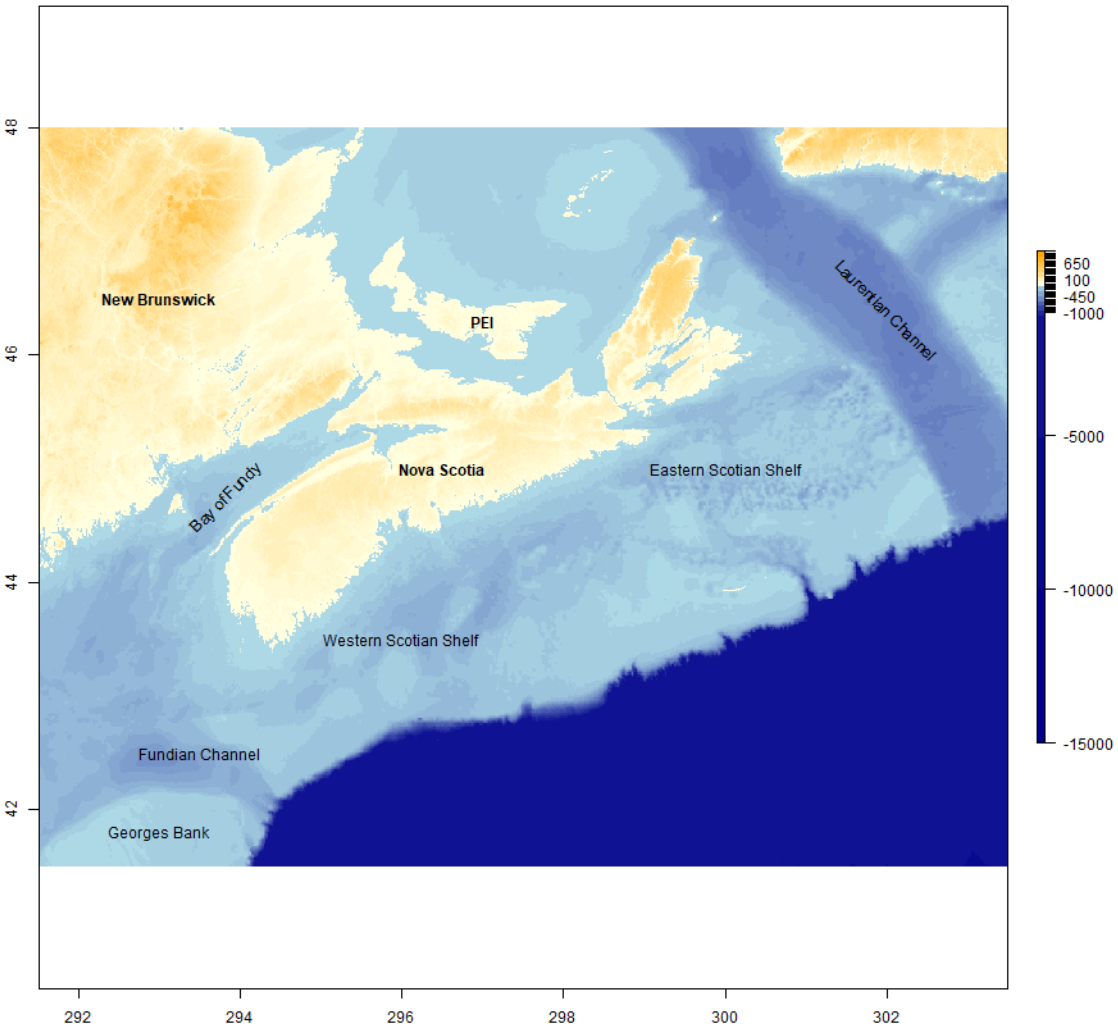

Figure 1. Map of the Scotian Shelf and Bay of Fundy.

2.2 Sampling Design

The summer survey covers divisions 4V, 4W and 4X of the Northwest Atlantic Fisheries Organization (NAFO) which includes the Scotian Shelf and the Bay of Fundy. The eastern limit of the survey is the Laurentian Channel and the western limit is the Fundian Channel (Figure 1).

The survey follows a stratified random design (Doubleday and Rivard 1981; Lohr 1999) (Figure 2). The number of tows conducted in each stratum is approximately proportional to its surface area.

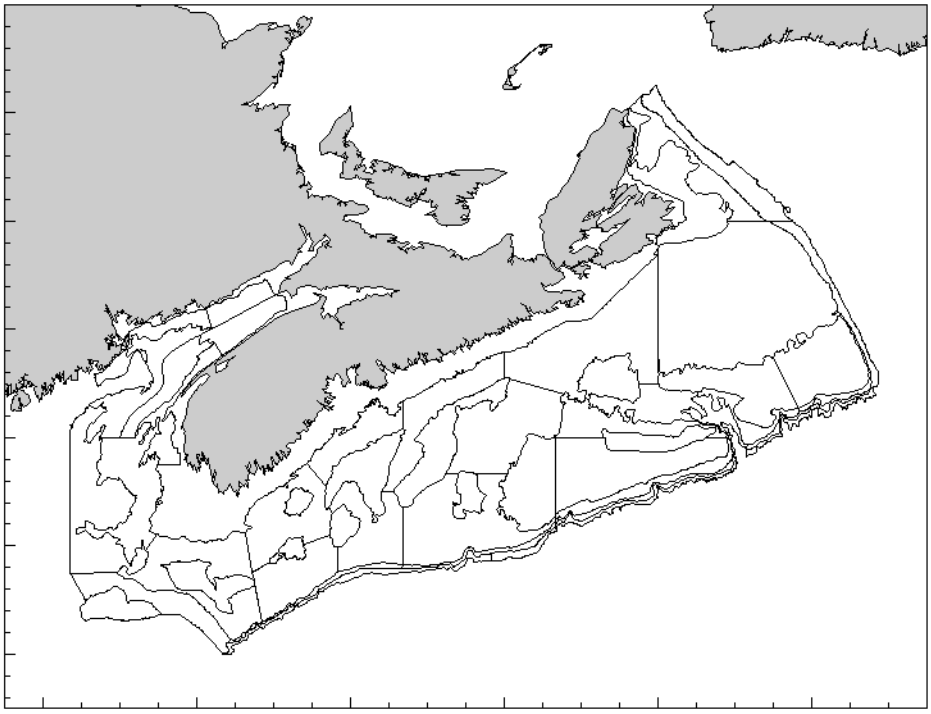

Figure 2. Map of the Summer survey strata.

The basic sampling unit of the survey is a 30-minute fishing tow conducted at a speed of 3.5 knots. This yields a distance towed of 1.75 nautical miles.

After each tow the catch is sorted by species and weighed. Each fish caught is then measured, and further sampling of individual fish weight, maturity status and age are performed for different length classes. When catches exceed 300 individuals, a random sub-sample is used to obtain the length and weight measurements.

The location of representative tows appears in Figure 3.

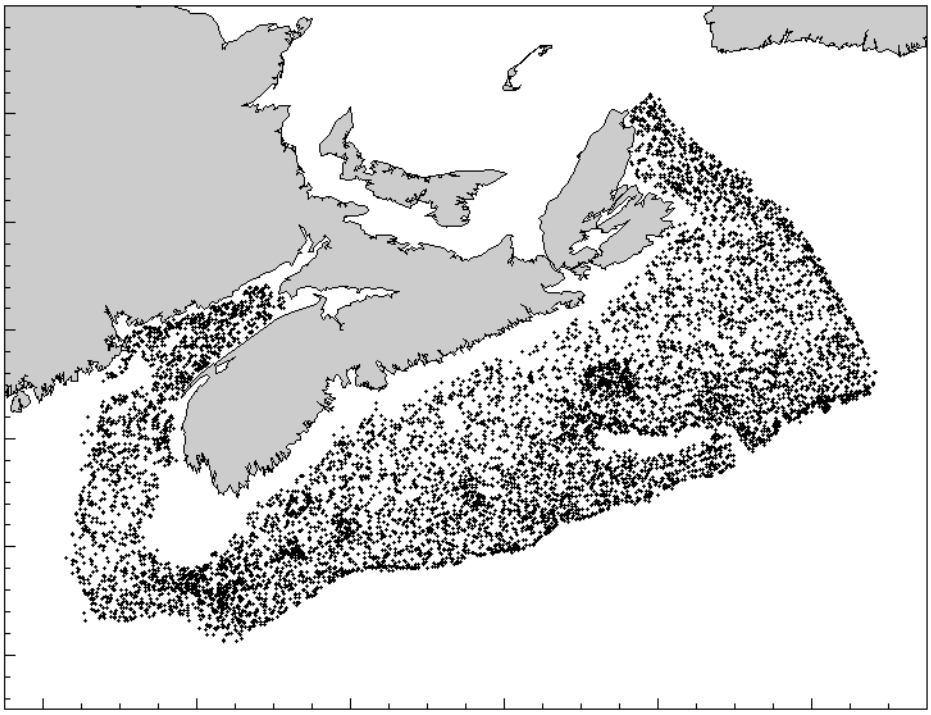

Figure 3. Map of the Summer survey tows.

2.3 Taxonomic Levels

Fish species caught during the surveys are identified by trained scientific personnel and their scientific name is determined. An internal species code used in the relational database is reported for each species (Losier and Waite 1989).

By its nature as a bottom trawl, the fishing gear used in the survey catches certain species better than others. To ensure that meaningful ecological information can be extracted from catch samples, we report the catch records for the subset of species that are caught reliably by the gear. To appear in this atlas, a species must have had a minimum of 10 observations over the duration of the survey activities. While both catch abundance and weight are recorded, the weight of species that appear at low abundances is often recorded as zero in the earlier parts of the survey when scales of appropriate precision were not available.

We divided the species caught into five categories based on 1) their taxonomic classification, 2) the number of recorded observations, and 3) their period of valid identification (Table 1). Category ”LF”, for ”long frequent”, was assigned to species that have more than 1000 records since 1970 and have been consistently identified since the onset of the survey. Category ”LI”, for ”long intermediate”, was assigned to species that had between 1000 and 200 catch records. Rare and elusive species (those with less than 200 catch records over the duration of the survey) are also reported but to a lower level of analytical details (Category ”LR”, for ”long rare”). Category ”SF”, for ”short frequent”, was assigned to invertebrate species that were consistently sampled only since 1999 (Tremblay M. J. 2007). And category ”SR”, for ”short rare” for invertebrate species consistently sampled only since 1999 and with less than 200 catch records. The list of taxa covered in this document is presented in phylogenetic order (Nelson J. S. et al. 2004) in Table 2. To ensure concordance with authoritative taxonomic information, the AphiaID from the World Register of Marine Species is also provided in Table 2 (Appeltans et al. 2012).

Category	**Name**	**Description**
L	long - consistently identified since the onset of the survey in 1970	
LF	long frequent	species that have more than 1000 catch records
LI	long intermediate	species that had between 1000 and 200 catch records
LR	long rare	species with less than 200 catch records
S	short - invertebrate species that were consistently sampled only since 1999	
SF	short frequent	species with more than 200 catch records
SR	short rare	species with less than 200 catch records

Table 1. Taxonomic levels

Table 2. List of species included in the Atlas. The species reported here are listed in phylogenetic order as per Page L. M. et al. (2013). For each taxonomic order and class, each species is listed in the table, its taxonomic family and scientific name is provided, along with its French and English common names, the species code used in the survey database, its AphiaID and a link to the World Registry of Marine Species, its number of catch records in the survey database and its classification category as defined in section 2.3.

Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Myxini							
Myxiniformes							
Myxinidae	*Myxine glutinosa*	Atlantic hagfish	Myxine du nord	241	101170	804	LI
Petromyzonti							
Petromyzontiformes							
Petromyzontidae	*Petromyzon marinus*	Sea lamprey	Lamproie marine	240	101174	16	LR
Actinopterygii							
Gadiformes							
Gadidae	*Gadus morhua*	Atlantic cod	Morue franche	10	126436	5451	LF
	Melanogrammus aeglefinus	Haddock	Aiglefin	11	126437	5827	LF
Phycidae	*Urophycis tenuis*	White hake	Merluche blanche	12	126504	3524	LF
	Urophycis chuss	Red hake	Merluche écureuil	13	126503	2195	LF
Merlucciidae	*Merluccius bilinearis*	Silver hake	Merlu argenté	14	158962	4936	LF
Lotidae	*Brosme brosme*	Cusk	Brosme	15	126447	688	LI
Gadidae	*Pollachius virens*	Pollock	Goberge	16	126441	2787	LF
	Microgadus tomcod	Atlantic tomcod	Poulamon atlantique	17	158928	44	LR
Merlucciidae	*Merluccius albidus*	Offshore silver hake	Merlu argenté du large	19	158748	161	LR
Scorpaeniformes							
Sebastidae	*Sebastes*	Atlantic redfishes	Sébastes de l'Atlantique	23	126175	4152	LF
Pleuronectiformes							
Pleuronectidae	*Hippoglossus hippoglossus*	Atlantic halibut	Flétan de l'Atlantique	30	127138	1634	LF

	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
		Reinhardtius hippoglossoides	Greenland halibut	Flétan noir	31	127144	736	LI
		Hippoglossoides platessoides	American plaice	Plie canadienne	40	127137	6023	LF
		Glyptocephalus cynoglossus	Witch flounder	Plie grise	41	127136	4301	LF
		Limanda ferruginea	Yellowtail flounder	Limande à queue jaune	42	158879	3233	LF
		Pseudopleuronectes americanus	Winter flounder	Limande-plie rouge	43	158885	1632	LF
	Paralichthyidae	*Citharichthys arctifrons*	Gulf Stream flounder	Plie du Gulf Stream	44	158791	382	LI
Perciformes								
	Anarhichadidae	*Anarhichas lupus*	Atlantic wolffish	Loup atlantique	50	126758	1572	LF
		Anarhichas minor	Spotted wolffish	Loup tacheté	51	126759	20	LR
		Anarhichas denticulatus	Northern wolffish	Loup à tête large	52	126757	17	LR
Clupeiformes								
	Clupeidae	*Clupea harengus*	Atlantic herring	Hareng de l'Atlantique	60	126417	3487	LF
		Alosa sapidissima	American shad	Alose savoureuse	61	158670	468	LI
		Alosa pseudoharengus	Alewife	Gaspareau	62	158669	977	LI
Osmeriformes								
	Osmeridae	*Osmerus mordax*	Rainbow smelt	Éperlan arc-en-ciel	63	126737	59	LR
		Mallotus villosus	Capelin	Capelan	64	126735	540	LI
Perciformes								
	Scombridae	*Scomber scombrus*	Atlantic mackerel	Maquereau commun	70	127023	696	LI
Gadiformes								

	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
	Phycidae	*Phycis chesteri*	Longfin hake	Merluche à longues nageoires	112	158988	784	LI
	Lotidae	*Enchelyopus cimbrius*	Fourbeard rockling	Motelle à quatre barbillons	114	126450	693	LI
Perciformes	Labridae	*Tautogolabrus adspersus*	Cunner	Tanche-tautogue	122	159785	82	LR
Scorpaeniformes	Sebastidae	*Helicolenus dactylopterus*	Blackbelly rosefish	Sébaste chèvre	123	127251	610	LI
Pleuronectiformes	Paralichthyidae	*Hippoglossina oblonga*	Fourspot flounder	Cardeau à quatre ocelles	142	158833	76	LR
	Scophthalmidae	*Scophthalmus aquosus*	Windowpane flounder	Turbot de sable	143	158907	115	LR
Aulopiformes	Chlorophthalmidae	*Parasudis truculenta*	Longnose greeneye	Oeil-vert à long nez	149	158868	45	LR
Myctophiformes	Myctophidae	*Myctophidae*	Lanternfishes	Poissons-lanternes	150	125498	160	LR
Aulopiformes	Chlorophthalmidae	*Chlorophthalmus agassizi*	Shortnose greeneye	Éperlan du large	156	126336	78	LR
Stomiiformes	Sternoptychidae	*Maurolicus muelleri*	Silvery lightfish	Brossé améthyste	158	127312	52	LR
	Stomiidae	*Stomias boa*	Boa dragonfish	Dragon-boa	159	127374	20	LR
Argentiniformes	Argentinidae	*Argentina silus*	Greater argentine	Grande argentine	160	126715	963	LI
Scorpaeniformes	Cottidae	*Myoxocephalus octodecemspinosus*	Longhorn sculpin	Chaboisseau à dix-huit épines	300	159520	3292	LF

	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
		Myoxocephalus scorpius	Shorthorn sculpin	Chaboisseau à épines courtes	301	127203	131	LR
		Myoxocephalus aenaeus	Grubby	Chaboisseau bronzé	303	159519	40	LR
		Triglops murrayi	Moustache sculpin	Faux-trigle armé	304	127205	1182	LF
		Artediellus uncinatus	Arctic hookear sculpin	Hameçon neigeux	306	127195	306	LI
	Psychrolutidae	*Cottunculus microps*	Polar sculpin	Cotte polaire	307	127235	29	LR
	Cottidae	*Icelus spatula*	Spatulate sculpin	Icèle spatulée	314	127200	40	LR
	Hemitripteridae	*Hemitripterus americanus*	Sea raven	Hémitriptère atlantique	320	159518	2126	LF
	Agonidae	*Aspidophoroides monopterygius*	Alligatorfish	Poisson-alligator atlantique	340	159459	1029	LF
		Ulcina olrikii	Arctic alligatorfish	Poisson-alligator arctique	341	274356	13	LR
		Leptagonus decagonus	Atlantic poacher	Agone atlantique	350	127191	266	LI
		Agonidae	Alligatorfishes	Poissons-alligator	351	125588	43	LR
Lophiiformes	Lophiidae	*Lophius americanus*	Monkfish	Baudroie d'Amérique	400	159184	1970	LF
Gadiformes	Macrouridae	*Nezumia bairdii*	Marlin-spike grenadier	Grenadier du Grand Banc	410	183289	529	LI
		Trachyrincus murrayi	Roughnose grenadier	Grenadier-scie	412	126481	18	LR
		Coryphaenoides rupestris	Roundnose grenadier	Grenadier de roche	414	158960	17	LR
Scorpaeniformes	Cyclopteridae	*Cyclopterus lumpus*	Lumpfish	Lompe	501	127214	216	LI

	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
		Eumicrotremus spinosus	Atlantic spiny lumpsucker	Petite poule de mer atlantique	502	127217	226	LI
	Liparidae	*Liparis atlanticus*	Atlantic seasnail	Limace atlantique	503	159524	34	LR
		Liparis fabricii	Gelatinous snailfish	Limace gélatineuse	505	127218	27	LR
		Liparis gibbus	Variegated snailfish	Limace marbée	512	159526	41	LR
		Careproctus reinhardti	Sea tadpole	Petite limace de mer	520	127212	18	LR
Perciformes	Zoarcidae	*Lycenchelys verrillii*	Wolf eelpout	Lycode à tête longue	603	159258	40	LR
Anguilliformes	Nemichthyidae	*Nemichthys scolopaceus*	Slender snipe eel	Avocette ruban	604	126306	28	LR
Perciformes	Ammodytidae	*Ammodytes dubius*	Sand lance	Lançon	610	151520	1283	LI
	Zoarcidae	*Lycodes terraenovae*	Newfoundland eelpout	Lycode du Labrador	619	127117	64	LR
		Lycodes lavalaei	Newfoundland eelpout	Lycode du Labrador	620	127107	72	LR
	Pholidae	*Pholis gunnellus*	Rock gunnel	Sigouine de roche	621	126996	21	LR
	Stichaeidae	*Lumpenus lampretaeformis*	Snakeblenny	Lompénie-serpent	622	154675	423	LI
		Leptoclinus maculatus	Daubed shanny	Lompénie tachetée	623	127072	443	LI
		Ulvaria subbifurcata	Radiated shanny	Ulvaire deux-lignes	625	159821	145	LR
		Eumesogrammus praecisus	Fourline snakeblenny	Quatre-lignes atlantique	626	159817	40	LR
	Cryptacanthodidae	*Cryptacanthodes maculatus*	Wrymouth	Terrassier tacheté	630	159675	120	LR
	Callionymidae	*Foetorepus agassizii*	Spotfin dragonet	Dragonnet tacheté	637	276339	20	LR

	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
	Zoarcidae	*Zoarces americanus*	Ocean pout	Loquette d'Amérique	640	159267	1478	LF
		Lycodes reticulatus	Arctic eelpout	Lycode arctique	641	127112	70	LR
		Melanostigma atlanticum	Atlantic soft pout	Molasse atlantique	646	127120	43	LR
		Lycodes vahlii	Vahl's eelpout	Lycode à carreaux	647	127118	565	LI
	Stromateidae	*Peprilus triacanthus*	Atlantic butterfish	Stromaté fossette	701	159828	487	LI
Zeiformes								
	Zeidae	*Zenopsis conchifer*	Silvery John dory	Saint Pierre argenté	704	127426	39	LR
Aulopiformes								
	Paralepididae	*Arctozenus risso*	White barracudina	Lussion blanc	712	126352	196	LR
Beloniformes								
	Scomberesocidae	*Scomberesox saurus*	Atlantic saury	Balaou atlantique	720	126392	37	LR
Stomiiformes								
	Sternoptychidae	*Sternoptychidae*	Hatchetfishes	Haches d'argent	741	125603	21	LR
Lophiiformes								
	Ogcocephalidae	*Dibranchus atlanticus*	Atlantic batfish	Malthe atlantique	742	126558	18	LR
Pleuronectiformes								
	Cynoglossidae	*Symphurus diomedeanus*	Spottedfin tonguefish	Langue fil noir	816	159358	24	LR
Scorpaeniformes								
	Cottidae	*Artediellus atlanticus*	Atlantic hookear sculpin	Hameçon atlantique	880	127193	258	LI
Elasmobranchii								
Rajiformes								
	Rajidae	*Dipturus laevis*	Barndoor skate	Grande raie	200	158548	246	LI
		Amblyraja radiata	Thorny skate	Raie épineuse	201	105865	3937	LF
		Malacoraja senta	Smooth skate	Raie lisse	202	158554	1773	LF

	Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
		Leucoraja erinacea	Little skate	Raie hérisson	203	158551	712	LI
		Leucoraja ocellata	Winter skate	Raie tachetée	204	158553	1180	LF
Squaliformes								
	Squalidae	*Squalus acanthias*	Picked dogfish	Aiguillat commun	220	105923	1985	LF
	Etmopteridae	*Centroscyllium fabricii*	Black dogfish	Aiguillat noir	221	105906	31	LR
Cephalopoda								
Oegopsida								
	Ommastrephidae	*Illex illecebrosus*	Northern shortfin squid	Encornet rouge nordique	4511	153087	4836	LF
Myopsida								
	Loliginidae	*Doryteuthis pealeii*	Longfin inshore squid	Calmar totam	4512	574541	96	LR
Malacostraca								
Decapoda								
	Pandalidae	*Pandalus borealis*	Northern prawn	Crevette nordique	2211	107649	718	SF
	Cancridae	*Cancer borealis*	Jonah crab	Tourteau jona	2511	158056	1387	SF
		Cancer irroratus	Atlantic rock crab	Tourteau poïnclos	2513	158057	788	SF
	Oregoniidae	*Hyas coarctatus*	Arctic lyre crab	Crabe Hyas coarctatus	2521	107323	711	SF
	Lithodidae	*Lithodes maja*	Atlantic king crab	Crabe épineux du nord	2523	107205	531	SF
	Oregoniidae	*Chionoecetes opilio*	Queen crab	Crabe des neiges	2526	107315	1546	SF
		Hyas araneus	Great spider crab	Crabe lyre araignée	2527	107322	625	SF
	Geryonidae	*Chaceon quinquedens*	Red deepsea crab	Crabe rouge	2532	158407	33	SR
	Nephropidae	*Homarus americanus*	American lobster	Homard américain	2550	156134	1623	SF

2.4 Analyses

The Oracle relational database where all data are stored was accessible from the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. Structured Query Language (SQL) is used to extract the data from the production server and to create the data products used in all subsequent analyses. Catch records classified as ”valid” (i.e. a representative tow without damage to the net) are used in the current analyses. To make the available samples comparable, catch number and weight for each species was standardized for the distance towed.

All data processing and analyses were conducted using the R software (R Core Team 2020) using packages gstat (Pebesma 2004), PBSmapping (Schnute et al. 2019), RODBC (Ripley and Lapsley 2019), spatstat (Baddeley 2015), maptools (Bivand and Lewin-Koh 2020), rgeos (Bivand and Rundel 2020), classInt(Bivand 2020), RColorBrewer(Neuwirth 2014), MASS (Ripley et al. 2020), worms (Holstein 2018), and tidyverse (Wickham 2019). The present document is rendered as a Technical Report using the csasdown R package developed and maintained by Fisheries and Oceans Canada scientists (Anderson et al. In press).

2.4.1 Geographic distribution of catches

Spatial interpolation of catch biomass (kg/tow) or abundance (number/tow) was done using a weighting inversely proportional to the distance, using function ”idw” of the spatstat R package (Baddeley 2015).

2.4.2 Abundance and biomass indices

For each species, stratified random estimates of catch abundance and biomass (Smith 1996) were computed for each year. Yearly estimates of the standard error were also computed.

2.4.3 Distribution indices

For each Category L, I and S fish species, the minimum area required to account for 75% and 95% of the total biomass or abundance were computed (D75% and D95%). These measures of distributions were computed for each year by using the Lorenz curve of mean stratum-level catch estimates and the area of occupied strata (Swain and Sinclair 1994; Swain and Morin 1996).

2.4.4 Length frequencies

The length frequency distribution of catch is tabulated for each seven-year period (1970-2009), and last ten-year period (2010-2020).

2.4.5 Length-weight relationship and condition factor

The relationship between the weight and the length of fish was estimated using the following non-linear isometric relationship:

$$W = \alpha L^{\beta}$$

where W is the total weight (g), L is the length (cm), and, α and β are the parameters to be estimated.

Average fish condition (C) was computed as:

$$C = \frac{W}{\alpha L^{\beta}}$$

2.4.6 Depth, temperature and salinity distribution of catches

For each category L species, We followed the methods developed by (Perry and Smith 1994) and generated cumulative frequency distributions of depth, temperature and salinity of survey catches.

2.4.7 Density-dependent habitat selection

We followed the methods of (Myers and Stokes 1989) to evaluate how fish abundance in each stratum varied with overall temporal fluctuations of population abundance.

For each category L species, we fitted a model of the relationship between stratum-level density and overall abundance (the yearly stratified random estimate of abundance, defined above). To properly use the observations of zero catch while accounting for the logarithmic distribution of catch abundance, we implemented the model as a generalised linear using a log link and a Poisson error distribution:

$$Y_{h,i} = \alpha_h Y_i^{\beta_h}$$

where, $y_{h,i}$ is the average abundance of stratum h in year i, and $\alpha_{h,i}$ and $\beta_{h,i}$ are the fitted parameters. The estimated parameter $\beta_{h,i}$ is referred to as the "slope parameter" and indicates whether stratum-level density is positively ($\beta_{h,i} <= 0$), negatively ($\beta_{h,i} >= 0$) or negligibly ($\beta_{h,i} \approx 0$) related to population abundance.

To estimate the suitability of each stratum, the median abundance observed during the years that are in the top 25% of yearly estimates is used. We combine the slope parameter estimates from the above model with the median abundance to identify strata that have consistently high abundance and whose local density is weakly related to fluctuation in population abundance ($\beta_{h,i} \approx 0$). Preferred strata are identified for each category L species.

3 Results

The plots generated for each species are presented in the Appendix.

3.1 Description of Figures

3.1.1 Type A

For Category L and S species:

Spatial distribution of catch-per unit of effort, (CPUE, kilograms per tow) in July-August for the Bay of Fundy and Scotian Shelf in five-year periods. Spatial interpolation between tows was done using Inverse Distance Weight (IDW). The probability of occurrence (proportion of tows with catch records for a given species) was also reported for each five-year period.

For Category LR and SR:

Location of tows with catch over the period 1970-2012 (Type LR) or the period 1999-2012 (Type SR). Location of tows with catch over the period 1970-2012 (Type LR) or the period 1999-2012 (Type SR).

3.1.2 Type B

For Category L, S and I species:

Stratified random estimate of CPUE (left panel), distribution indices (D75% and D95%, the minimum area containing 75% and 95% of biomass, middle panel), and distribution vs. weight per tow (right panel). The stratified random mean is plotted as a solid line with the 95% confidence region indicated by the solid grey line. The overall mean is plotted as a grey horizontal line and the overall mean plus or minus 50% of the standard deviation appear as horizontal dashed lines. In all three panels, the early years appear in blue and the last years appear in red. The predictions from a loess estimator are overlaid on the distribution indices (middle panel). The Pearson correlation coefficient between D75% and biomass, and its statistical significance, are also reported in the right panel.

3.1.3 Type C.

Length frequency distribution for NAFO divisions 4X and 4VW. A smoothed length frequency distribution is shown for each 7-year periods covered by the surveys.

3.1.4 Type D.

Average fish condition for all fish lengths (black dots and black line), large fish (thick gray line), and small fish (thin gray line). Fish condition is presented for NAFO divisions 4VW (right panel) and 4X (left panel).

3.1.5 Type E.

Cumulative frequency distributions of depth, temperature and salinity at all sampled locations (thick solid line) and at fishing locations with catch records (thin dashed line). The depth, temperature and salinity associated with 5%, 25%, 50%, 75% and 95% of the cumulative catch is shown in tabular fashion on the bottom right panel.

3.1.6 Type F.

Slopes estimates from the density-dependent habitat selection model (y axis) plotted versus the median abundance during the top 25% of years. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance. Each stratum is identified on the plot by the last two digits of its number.

3.2 Summary of successful tows by year and stratum

There is something weird going on here, there are 2 tows with NAs for stratum, (HAM1980042 set 62 and HAM1982072 set 13).

404 < !– Number of tows by stratum-year –>

Table 3. Number of representative tows conducted in each stratum during the period 1970 to 1991.

Stratum	NAFO Div.	Area (km2)	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
440	4VN	3173.016	4	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	5	5	6	4	4	4
441	4VN	3434.000	4	2	2	3	3	3	1	3	3	3	3	3	3	3	3	5	5	4	4	4	6	5
442	4VN	4934.658	3	2	2	2	3	3	2	3	3	3	3	3	3	3	3	3	5	6	7	5	5	5
443	4VSW	4526.012	4	2	4	4	8	3	1	2	4	4	4	3	5	4	4	4	6	6	5	2	4	2
444	4VSW	13478.450	3	2	5	4	6	4	6	7	4	4	4	5	5	6	4	4	6	6	3	6	7	8
445	4VSW	3512.982	5	2	5	4	5	5	1	3	4	4	4	5	5	3	4	5	6	4	4	4	4	4
446	4VSW	1686.094	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3
447	4VSW	5549.344	4	2	6	5	7	4	4	3	4	4	5	4	4	4	4	4	5	7	6	6	8	7
448	4VSW	4975.866	5	2	5	4	5	4	4	4	4	4	4	6	4	4	4	4	5	5	5	5	9	6
449	4VSW	494.496	2	2	2	2	3	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2
450	4VSW	1315.222	2	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
451	4VSW	504.798	1	2	2	2	2	2	2	2	2	3	2	2	3	2	2	2	2	2	2	2	2	2
452	4VSW	1184.730	2	2	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	3	2	2	3	2
453	4VSW	889.406	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	3	2
454	4VSW	1713.566	3	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	2	2	2	3	2
455	4VSW	7286.948	7	6	7	6	7	6	6	7	7	7	7	7	7	7	7	7	8	8	7	7	12	10
456	4VSW	3279.470	5	4	6	5	5	6	4	6	6	6	6	7	6	6	6	6	6	7	6	6	10	7
457	4VSW	2784.974	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	4	2	2	4	2
458	4VSW	2259.572	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	3	3	9	8
459	4VSW	10810.232	3	2	4	4	4	4	4	4	4	4	4	4	3	4	4	6	6	5	6	5	5	5
460	4VSW	4615.296	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	4	3	3	3	3	3
461	4VSW	3962.836	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2	1	2
462	4VSW	7266.344	3	3	4	3	4	4	4	4	4	4	6	4	4	4	4	4	6	5	4	4	5	5
463	4VSW	1037.068	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	3	2
464	4VSW	4453.898	4	3	5	3	3	6	5	5	5	5	5	5	4	5	5	5	7	6	5	5	9	7
465	4VSW	8183.222	6	5	5	4	5	4	5	5	5	5	5	7	6	5	5	5	5	8	8	8	12	9
466	4VSW	776.084	2	2	3	2	3	3	3	3	3	3	3	2	3	3	3	3	3	2	2	2	3	2
470	4X	3159.280	1	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	2
471	4X	3447.736	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
472	4X	4289.066	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	4	4	4	6	4
473	4X	910.010	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
474	4X	552.874	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2
475	4X	535.704	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
476	4X	5075.452	2	2	2	2	2	3	2	2	2	1	2	2	2	2	2	2	2	4	4	4	4	4
477	4X	4230.688	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	5	4	4	5	5
478	4X	800.122	2	2	3	2	3	3	3	3	2	3	3	3	3	3	3	3	3	2	2	2	2	2
480	4X	2249.270	4	4	4	3	3	3	4	4	3	4	3	3	4	4	4	4	4	4	4	4	8	8
481	4X	6438.750	5	3	4	4	4	3	4	4	5	4	3	4	4	4	4	4	4	6	7	6	8	9
482	4X	3578.228	2	1	2	2	2	2	3	2	2	3	2	2	2	2	2	2	2	3	3	3	3	3
483	4X	1826.888	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
484	4X	7774.576	2	2	3	3	3	3	3	3	2	3	3	3	4	3	3	3	3	4	4	4	3	3
485	4X	5432.588	2	2	2	3	3	3	3	3	3	3	2	3	4	3	3	3	3	6	7	6	2	3
490	4X	2063.834	2	2	2	2	2	3	3	3	3	2	3	3	3	3	3	3	3	4	4	4	4	4
491	4X	2359.158	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	3	3
492	4X	3729.324	3	2	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	3	3
493	4X	1830.322	1	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
494	4X	1431.978	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
495	4X	2005.456	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2
		171809.888	134	110	146	134	153	143	135	144	141	147	145	150	150	146	143	152	171	188	177	170	213	189

Table 4. Number of representative tows conducted in each stratum during the period 1992 to 2013.

Stratum	NAFO Div.	Area (km2)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
440	4VN	3173.016	4	3	4	4	4	4	4	4	6	4	4	4	4	4	4	4	3	4	4	5	4	4
441	4VN	3434.000	5	5	5	5	5	5	5	6	7	6	6	7	6	7	6	6	5	6	6	7	6	6
442	4VN	4934.658	6	5	6	6	6	6	6	7	6	6	5	6	6	7	5	5	5	6	5	6	6	6
443	4VSW	4526.012	4	3	3	4	4	5	5	4	5	4	5	5	5	4	4	4	5	4	4	6	5	5
444	4VSW	13478.450	8	9	6	8	8	7	8	8	9	10	9	9	9	8	10	8	6	9	11	13	9	8
445	4VSW	3512.982	4	5	7	4	4	4	3	3	6	5	5	5	5	6	5	4	3	6	4	7	2	4
446	4VSW	1686.094	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	4	3	3
447	4VSW	5549.344	7	7	7	7	6	7	7	6	7	7	7	7	7	7	6	6	4	6	6	8	6	7
448	4VSW	4975.866	6	7	7	7	6	7	6	7	8	8	8	8	7	8	8	6	5	7	7	10	8	8
449	4VSW	494.496	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	4	2	2
450	4VSW	1315.222	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
451	4VSW	504.798	2	2	2	2	4	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2
452	4VSW	1184.730	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2
453	4VSW	889.406	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	1	2	2	1	3	2
454	4VSW	1713.566	2	2	2	2	3	2	2	2	2	2	2	2	2	3	2	2	2	2	2	4	2	2
455	4VSW	7286.948	10	9	10	10	10	13	8	11	11	11	11	11	8	12	11	7	5	8	10	10	10	11
456	4VSW	3279.470	7	8	8	8	8	8	6	8	10	8	8	8	8	8	8	6	2	7	7	9	8	8
457	4VSW	2784.974	2	2	2	2	2	2	2	1	4	2	2	2	2	2	2	2	2	2	2	4	2	2
458	4VSW	2259.572	8	8	8	8	7	8	5	6	10	8	7	8	8	10	8	5	2	7	6	9	8	6
459	4VSW	10810.232	6	4	6	6	4	5	6	6	8	6	6	6	6	6	6	5	3	6	6	7	6	6
460	4VSW	4615.296	3	3	3	3	3	3	3	3	3	3	4	3	3	4	3	2	3	3	3	4	4	3
461	4VSW	3962.836	2	2	2	2	2	2	2	2	2	2	2	2	2	4	2	2	2	2	2	3	3	2
462	4VSW	7266.344	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	3	4	4	4	6	4	4
463	4VSW	1037.068	2	2	2	2	2	2	2	2	2	2	3	2	2	4	2	2	2	2	2	3	2	2
464	4VSW	4453.898	7	7	7	7	7	4	7	7	7	7	7	7	5	8	7	6	4	5	6	7	7	7
465	4VSW	8183.222	10	10	10	10	10	10	9	10	10	10	10	10	10	10	10	7	8	7	8	10	10	10
466	4VSW	776.084	2	2	2	3	2	2	3	2	2	2	2	2	2	2	2	1	3	2	2	2	2	2
470	4X	3159.280	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
471	4X	3447.736	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
472	4X	4289.066	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	3	4	3	4	6	4	4
473	4X	910.010	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2
474	4X	552.874	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
475	4X	535.704	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2
476	4X	5075.452	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4
477	4X	4230.688	5	5	5	5	5	5	5	5	5	5	5	5	5	8	5	5	5	5	5	4	5	5
478	4X	800.122	2	2	2	3	3	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2
480	4X	2249.270	8	8	8	8	8	8	8	8	7	8	8	8	7	9	8	6	8	8	8	7	8	8
481	4X	6438.750	9	9	9	7	9	9	9	9	8	9	8	9	6	12	9	7	8	8	8	10	9	9
482	4X	3578.228	3	3	3	3	3	3	3	3	3	3	3	3	2	4	3	3	3	3	3	4	3	3
483	4X	1826.888	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2
484	4X	7774.576	3	3	3	3	3	3	3	3	3	3	4	3	3	4	4	3	3	4	3	5	5	5
485	4X	5432.588	3	3	3	3	3	3	3	3	4	3	5	5	3	2	5	4	5	5	5	6	5	5
490	4X	2063.834	4	4	4	5	4	4	4	3	4	4	4	6	4	3	3	3	4	3	3	4	2	4
491	4X	2359.158	3	3	3	3	3	3	3	3	3	3	3	5	3	3	4	3	4	4	4	4	4	4
492	4X	3729.324	3	3	3	2	3	3	3	3	3	3	3	5	2	3	4	4	4	4	4	6	4	4
493	4X	1830.322	3	3	3	3	2	3	3	2	3	3	4	5	2	4	4	3	3	4	3	4	4	4
494	4X	1431.978	2	2	2	2	2	2	2	2	2	2	3	4	2	2	4	3	3	4	4	4	4	4
495	4X	2005.456	2	2	2	2	2	2	2	2	2	2	2	4	2	2	5	3	3	4	3	4	4	4
		171809.888	193	190	195	195	191	193	186	191	213	201	208	216	188	222	209	177	165	196	196	243	210	208

Table 5. Number of representative tows conducted in each stratum during the period 2014 to 2020 and for the whole 1970 to 2020 period.

Stratum	NAFO Div.	Area (km2)	2014	2015	2016	2017	2018	2019	2020	Total
440	4VN	3173.016	4	4	4	4	0	5	4	190
441	4VN	3434.000	6	6	6	6	0	7	4	238
442	4VN	4934.658	6	6	6	6	0	6	5	240
443	4VSW	4526.012	3	7	4	5	0	9	4	214
444	4VSW	13478.450	9	9	11	10	0	6	8	352
445	4VSW	3512.982	3	4	4	4	0	6	3	215
446	4VSW	1686.094	3	2	3	2	0	3	2	145
447	4VSW	5549.344	7	7	7	7	0	6	5	291
448	4VSW	4975.866	8	7	6	6	0	7	4	299
449	4VSW	494.496	2	2	2	2	0	2	2	100
450	4VSW	1315.222	3	3	3	2	0	3	2	144
451	4VSW	504.798	2	2	2	2	0	2	2	104
452	4VSW	1184.730	1	4	3	3	0	3	3	110
453	4VSW	889.406	3	2	2	1	0	2	2	116
454	4VSW	1713.566	2	2	2	2	0	3	2	121
455	4VSW	7286.948	11	9	9	8	0	9	6	429
456	4VSW	3279.470	6	5	6	6	0	6	4	331
457	4VSW	2784.974	2	3	3	3	0	3	2	113
458	4VSW	2259.572	4	5	5	5	0	6	3	269
459	4VSW	10810.232	6	7	7	6	0	9	7	262
460	4VSW	4615.296	3	5	5	5	3	6	5	151
461	4VSW	3962.836	2	3	3	3	2	3	3	113
462	4VSW	7266.344	5	5	5	5	0	5	5	212
463	4VSW	1037.068	2	3	2	2	0	2	2	107
464	4VSW	4453.898	7	6	6	4	0	6	4	288
465	4VSW	8183.222	10	10	9	7	3	10	7	397
466	4VSW	776.084	2	2	2	3	0	3	2	118
470	4X	3159.280	2	3	3	3	4	3	2	112
471	4X	3447.736	2	3	3	3	4	4	3	110
472	4X	4289.066	4	4	4	4	4	4	4	172
473	4X	910.010	2	2	2	2	2	2	2	104
474	4X	552.874	2	2	2	2	2	2	2	100
475	4X	535.704	2	2	2	2	2	2	2	103
476	4X	5075.452	4	5	5	5	5	5	5	177
477	4X	4230.688	6	5	5	4	4	6	4	204
478	4X	800.122	2	2	2	3	2	2	2	119
480	4X	2249.270	6	7	7	7	5	7	5	306
481	4X	6438.750	9	8	10	9	6	9	6	350
482	4X	3578.228	3	3	4	4	3	4	3	141
483	4X	1826.888	2	2	3	3	2	3	2	105
484	4X	7774.576	4	6	5	7	7	7	7	186
485	4X	5432.588	5	6	6	6	4	6	5	196
490	4X	2063.834	3	4	4	4	3	4	3	173
491	4X	2359.158	4	4	4	4	3	4	3	168
492	4X	3729.324	4	3	4	4	3	4	4	171
493	4X	1830.322	3	3	4	6	3	3	3	159
494	4X	1431.978	3	4	4	3	2	4	3	128
495	4X	2005.456	2	4	4	4	3	4	3	127
		171809.888	196	212	214	208	81	227	175	9080

A total of 9080 representative tows were conducted for the period spanning from 1970 to 2020.

4 Discussion

This report builds on previous work and former atlases by updating a comprehensive suite of indices to give a snapshot of population status and environmental preferences of 104 fish and invertebrate species. The current document is not meant to replace stock assessments, species-specific analyses of abundance, biomass and distribution, or any targeted attempts to integrate information about species or group of species from the wide and disparate sources of data about marine organisms in the area covered by the DFO Maritimes summer trawl survey. It is rather meant to provide a reproducible set of tools to extract and visualize the information collected in the summer groundfish research vessel survey. It is hoped that this document can provide a stepping stone to conduct other ecological analyses using the trawl survey data and increase reproducibility and transparency of ecological information collected annually.

4.1 Diversity of approaches used for mapping fish and invertebrates in the Scotian Shelf bioregion

Different methods have been applied in the Northwest Atlantic, and specifically on the Scotian Shelf bioregion, to map fish and invertebrate species distribution. The present report, for example, builds upon the atlas of important habitat developed to map the persistence of relatively high biomass for key fish species using the summer groundfish research vessel survey (Horsman and Shackell 2009). Important habitat was obtained by interpolating observed weight per each species using the IDW, and calculating areas with relatively persistent high biomass for periods representing different fishery management eras. To compliment information from this atlas, including additional representations of biomass and diversity, a similar IDW interpolation mapping procedure was followed by Smith et al. (2015), Ward-Paige and Bundy (2015), and Bundy et al. (2017). The summer groundfish research vessel survey is typically conducted during the month of July. However, from the fall of 1978 through to the spring of 1985, DFO also conducted spring and fall surveys using the same sampling design. This unique seasonal data was used to map the seasonal spatial distribution of key demersal and other fish species using IDW interpolation on the Scotian Shelf from the spring, summer and fall between 1978 and 1985 (Smith et al. 2015). Following recommendations provided by Kenchington and Kenchington (2017), the spatial distribution of three indicators of biodiversity for fish and invertebrates were mapped using IDW interpolation to identify areas with persistently high values across fishery management eras, and compared with areas of persistently high abundance for selected species (Ward-Paige and Bundy 2015). This analysis revealed a lack of consistent relationships between areas of persist high diversity and persistent high biomass, suggesting that both can be used as independent and important spatial indicators of the system (Ward-Paige and Bundy 2015). Groupings of fishes and invertebrates based on size, habitat and feeding guild, were also mapped using IDW interpolations to identify hotspots of functional group diversity (Bundy et al. 2017). This analysis revealed a spatially and temporally variable distribution of functional diversity across the Scotian Shelf with notable areas of high and low diversity (Bundy et al. 2017). Top quintiles of each functional group using the IDW approach were used as representative layers for fish

and invertebrates in the MPA Network design in the Scotian Shelf Bioregion (Serdynska et al. In press). IDW interpolation methods have also been used to map the distribution of individual species such as sea cucumbers (*Cucumaria frondosa*) in the Scotian Shelf bioregion (Shackell et al. 2013a), and sea scallop (*Placopecten magellanicus*) in Georges and Browns Bank (Shackell et al. 2013b).

Species Distribution Modelling (SDM), instead of IDW, can also be used to evaluate spatio-temporal dynamics by predicting and understanding past, present and future distribution of species using environmental predictors (Robinson et al. 2017). A variety of modelling approaches are being implemented in Maritimes Region to map and predict fish and invertebrate species distribution by incorporating environmental predictors to account for seasonal and temporal variability. For example, a stock assessment of snow crab (*Chionoecetes opilio*) on the Scotian Shelf used data from the snow crab survey from 2005 to 2018 to map spatial data products for this stock, including annual predicted interpolations of potential habitat using Generalized Additive Models (GAM) and several environmental covariates including depth, curvature, slope, species composition, and annual temperature (Zisserson et al. 2019). Sea scallop predicted habitat using Maximum Entropy (MaxEnt) models were computed in the German Bank using data compiled via benthic habitat mapping and seafloor geotechnical surveys in 2006, 2009, and 2010 (Brown et al. 2012). Predictions in the Scotian Shelf bioregion and the Northeast United States using datasets from DFO and the National Oceanic and Atmospheric Administration from 1993 to 2012 also predicted sea scallop habitat at a wider scale based on three scenarios of seasonal temperature and salinity climatologies (NOAA) (Lowen et al. 2019). Offshore American lobster stock assessments (*Homarus americanus*) used data from the RV, DFO Georges Bank, and National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) bottom trawl surveys (1970 to 2015) to predict species distribution using boosted regression trees and several environmental predictors (bathymetry, slope, curvature, and annual temperature interpolations) (Cook et al. 2017). Information on the potential for recovery of cusk (*Brosme brosme*) used data from the bottom longline Halibut industry survey and Cusk absences in the Summer groundfish research vessel survey from 1998-2013 to predict suitable habitat using GAM, MaxEnt, and random forest models and several physical environmental variables (e.g. complexity, benthic current stress and complexity, temperature, salinity, primary production, chlorophyll, suspended matter) (Harris et al. 2018). Atlantic halibut (*Hippoglossus hippoglossus*) assessments using Summer groundfish research vessel survey and NOAA survey data from 2001 to 2013 predicted juvenile habitat using MaxEnt model and environmental predictors (bathymetry, slope, bottom temperature) (French et al. 2018). Persistent areas of high Atlantic halibut juvenile abundance were predicted using data from 27 bottom trawl surveys combined (NMFS and DFO) from 1978 to 2013 and applying Bayesian hierarchical spatiotemporal models with two environmental predictors (depth and temperature) (Boudreau et al. 2017).

These examples of mapping efforts in Maritimes Region showcase the diversity of approaches relevant to a variety of important research questions and management applications. Approaches, methods, datasets, and environmental predictors are selected based on individual project research questions, and considerations for each species, communities or stock. This allows research groups to maintain innovation and keep up with emerging methods and technologies to improve assessments, predictions, and ultimately, science advice. The diversity of approaches also leads to complexity when looking across studies as each data compilation and predictive method carries its own independent assumptions and can lead to different spatial outputs.

4.2 Interpreting spatial results for marine spatial planning purposes

Fisheries and Oceans Canada is leading a marine spatial planning process that brings together relevant authorities and stakeholders to better coordinate how we use and manage marine spaces to achieve ecological, economic and social objectives. Operationalizing marine spatial planning includes a series of steps, including the process of analyzing existing conditions by collecting and mapping information about ecological, environmental and oceanographic conditions (Ehler and Douvere 2009; Agardy et al. 2011). Mapping the distribution of species is critical for the implementation of spatial management and as a first step in marine spatial planning processes. Species distribution have supported the identification of important sites for a given species or areas of high richness and diversity, which in turn can be used to inform siting decisions of new activities such as Marine Protected Areas (MPA), aquaculture sites or wind turbines. In the Scotian Shelf bioregion, mapping species distributions has been used to highlight areas of high biological diversity to support the identification of Ecologically or Biologically Significant Areas [Ricard and Shackell (2013); Ward-Paige and Bundy (2015)), to distinguish important and persistent habitat of significant species and functional groups to support MPA and conservation planning (Horsman and Shackell 2009; Smith et al. 2015; Ward-Paige and Bundy 2015; Bundy et al. 2017), to identify important habitat for Species at Risk (Harris et al. 2018) and to highlight reserves for data-poor invertebrate fisheries (Shackell et al. 2013a). Mapping species distribution has also been used to illustrate multi-decadal scale projections of changes in species distribution in the context of climate change and adaption (Stanley et al. 2018; W. et al. 2019).

In support of the marine spatial planning process, a public web-based atlas with relevant geospatial information is being developed to support decision-making. This Atlantic Canada-wide compilation of data and information will be a web-based, public platform with interactive maps of ocean ecosystems, human uses and management areas. This atlas cannot host the vast diversity of products and mapping approaches available in Maritimes Region. Consequently, we recommend that data products presented in this report should not be used for the atlas until an evaluation of the spatial information available and used in the past, is conducted.

This diverse portfolio of approaches and applications is not unique to the Maritimes Region. A recent review of global distribution modelling efforts recommended the adoption of a consistent framework that integrates multi-model approaches and a clear expression of errors and uncertainties (Robinson et al. 2017). In this context, Pacific Region has developed two initiatives to enable consistency and frequent publication, reproducibility, and transparency. One initiative developed a fully automated reproducible report to give a synthesis of data availability, population trends, fishing trends, growth and maturity patterns for 113 groundfish species in British Columbia to support stock assessment (Anderson et al. 2019). The second initiative developed a SDM framework that was applied to twelve species on Canada's Pacific coast as part of the Regional Response Plan (Nephin et al. 2019). The Maritimes and Gulf region, through this and past reports, are also using similar reproducible approaches to facilitate annual updates and transparency (Ricard and Shackell 2013; Ricard and Gomez 2021).

Recognizing the diversity of approaches for mapping fish and invertebrates in the Scotian Shelf bioregion, we recommend the development of a regional community of practice to compare and evaluate approaches for mapping, interpolating and/or modelling fish and invertebrates so future publications and advice related to spatial outputs can lead to more comparable work and consistent science advice to support processes such as marine spatial planning. At the

international level, guidelines and standards related to appropriate variables and methods for mapping and modeling species and communities of deep-sea habitats were proposed to encourage the production of publications that will lead to more comparable work (Kenchington et al. 2019). Similar general guidance for group practice approach mapping would be a worthwhile product in Maritimes Region. Until then, we proposed the use of the Open Data record (DFO 2021) for the version 1.0 of the public web-based atlas.

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7 Appendix

7.1 Atlantic cod (Morue franche) - species code 10 (category LF)

Scientific name: Gadus morhua

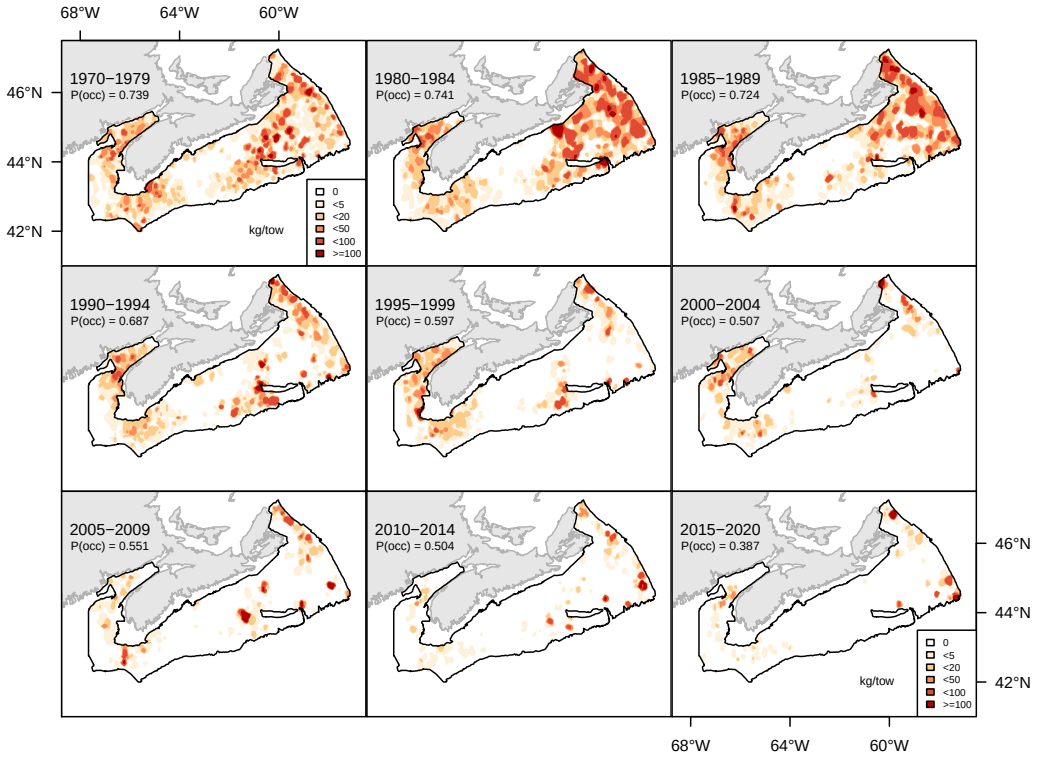


Figure 7.1A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic cod.

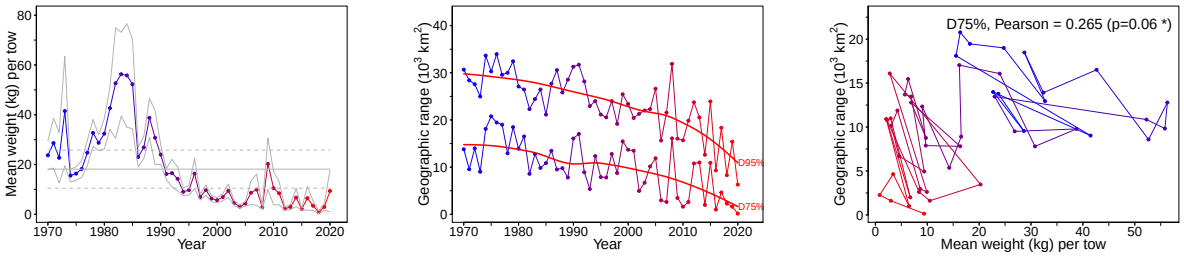


Figure 7.1B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic cod.

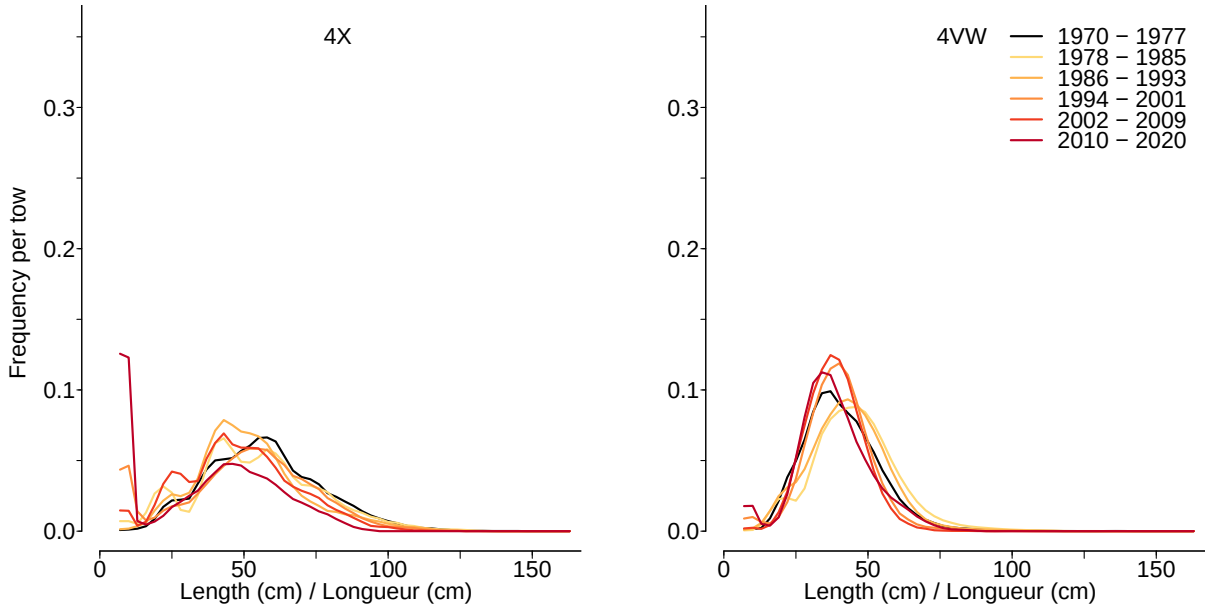


Figure 7.1C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic cod.

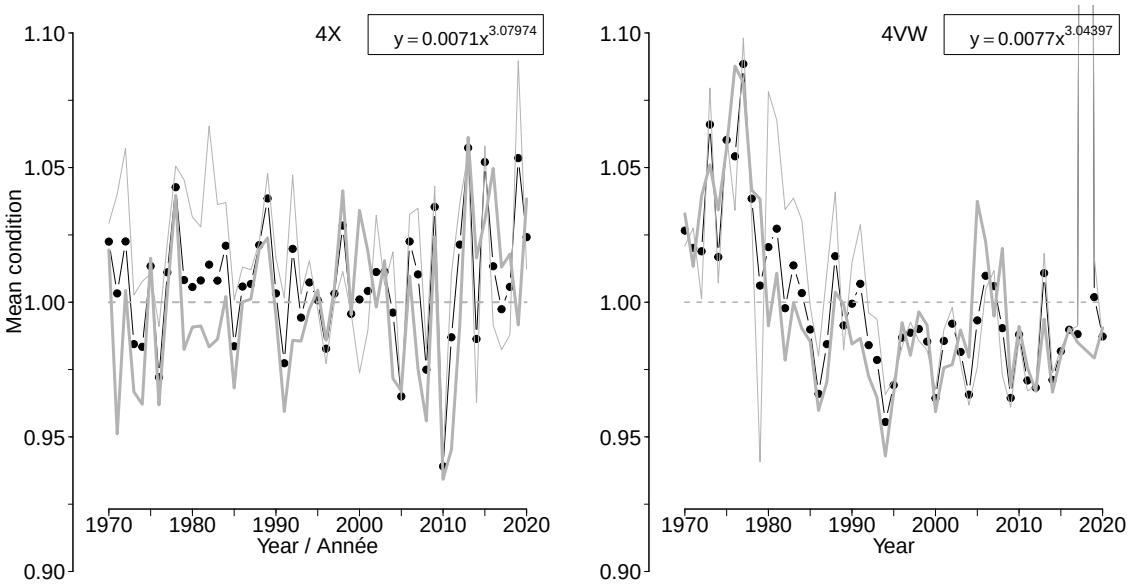
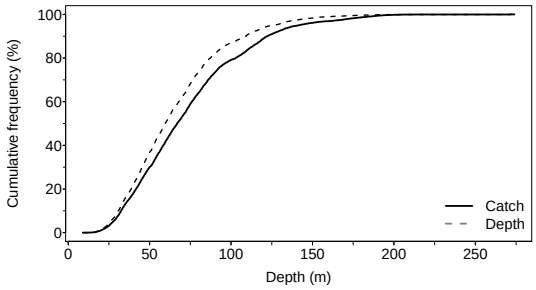
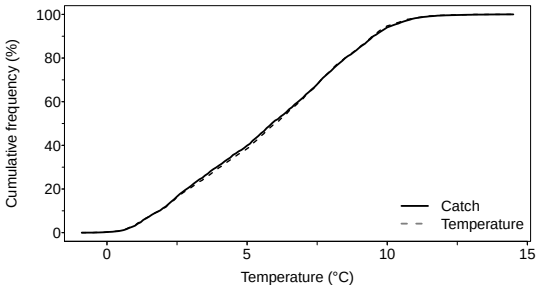
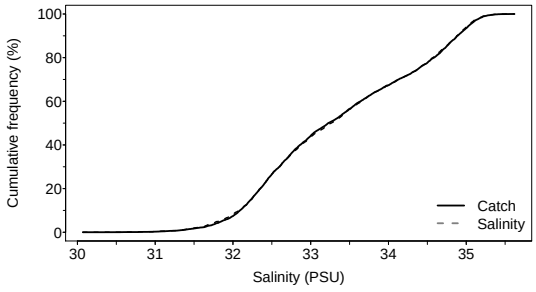


Figure 7.1D. Average fish condition in NAFO units 4X and 4VW for Atlantic cod.







Freq	Depth	Temp	Sal
F5	26	1.2	31.00
F25	43	3.5	32.47
F50	60	6.0	33.27
F75	82	8.1	34.40
F95	126	10.0	35.03

Figure 7.1E. Catch distribution by depth, temperature and salinity of Atlantic cod.

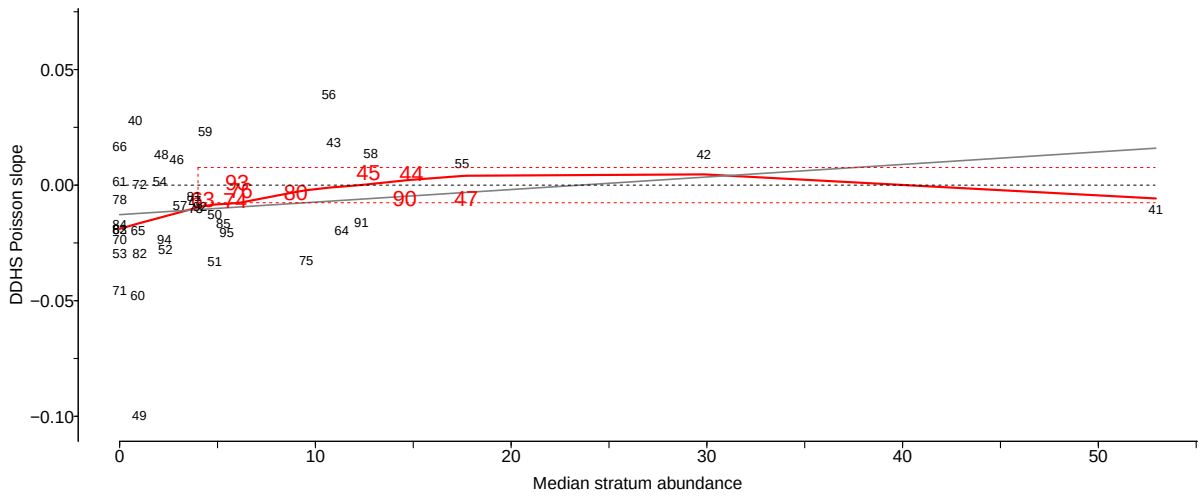


Figure 7.1F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic cod.

7.2 Haddock (Aiglefin) - species code 11 (category LF)

Scientific name: Melanogrammus aeglefinus

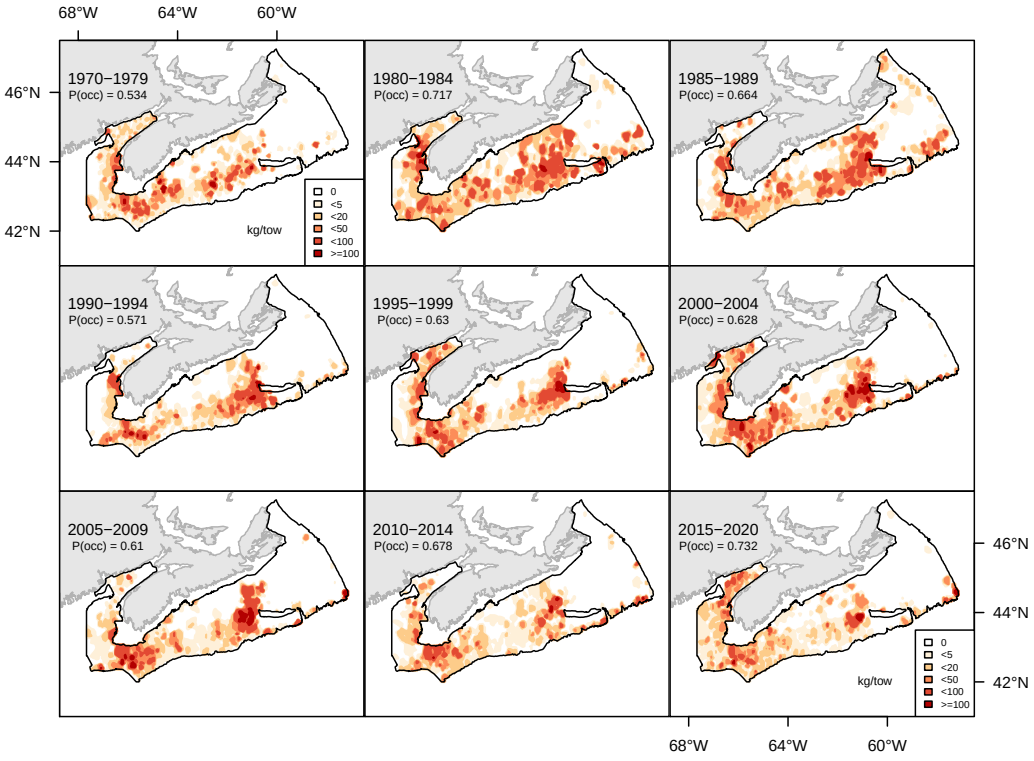


Figure 7.2A. Inverse distance weighted distribution of catch biomass (kg/tow) for Haddock.

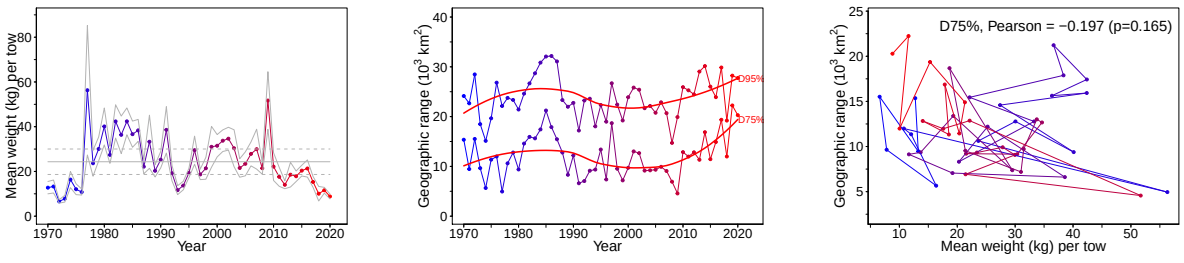


Figure 7.2B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Haddock.

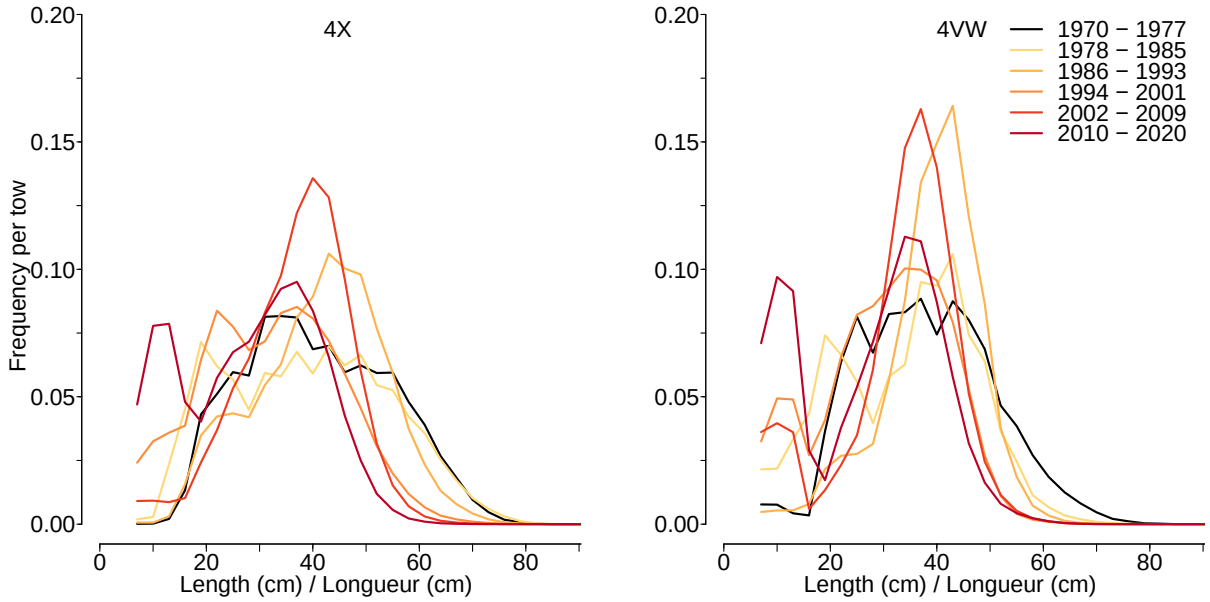


Figure 7.2C. Length frequency distribution in NAFO units 4X and 4VW for Haddock.

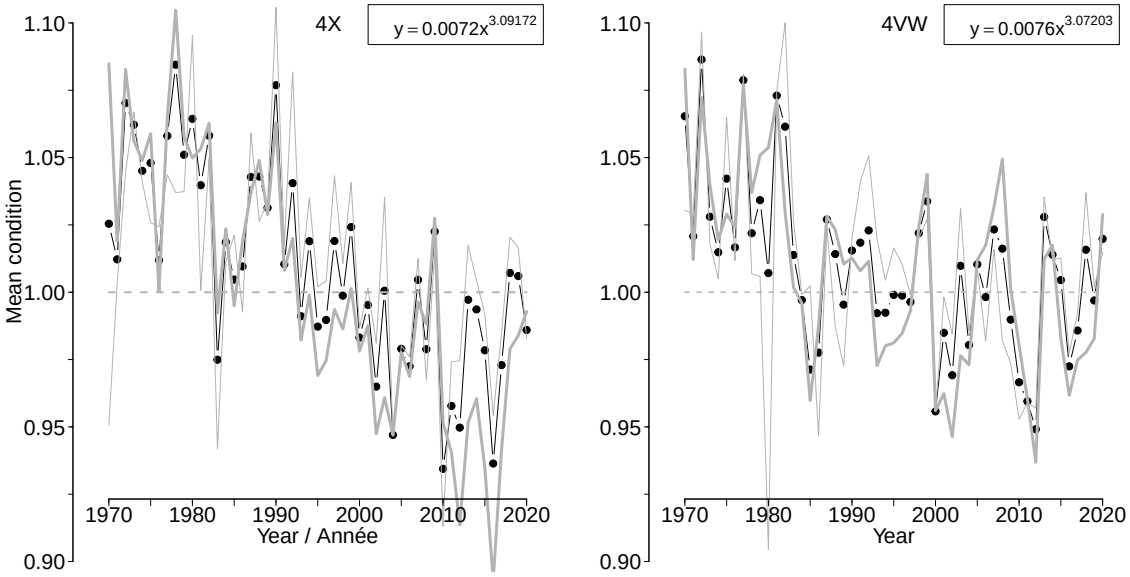
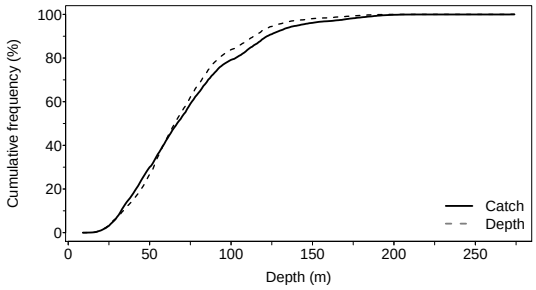
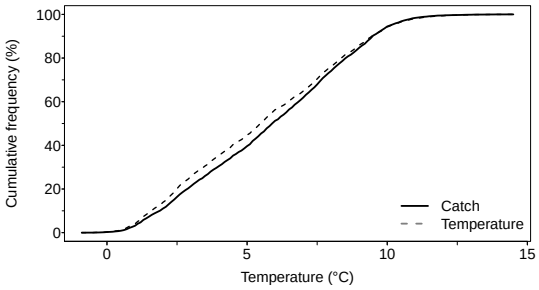
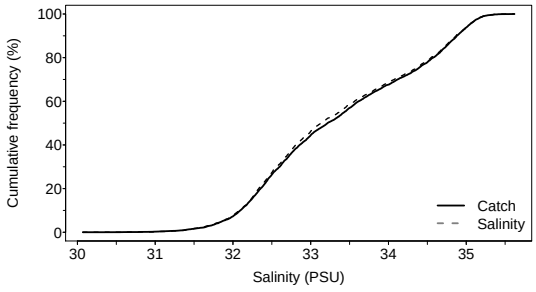


Figure 7.2D. Average fish condition in NAFO units 4X and 4VW for Haddock.







Freq	Depth	Temp	Sal
F5	27	1.1	31.00
F25	49	3.0	32.45
F50	66	5.5	33.14
F75	87	7.9	34.36
F95	127	10.0	35.03

Figure 7.2E. Catch distribution by depth, temperature and salinity of Haddock.

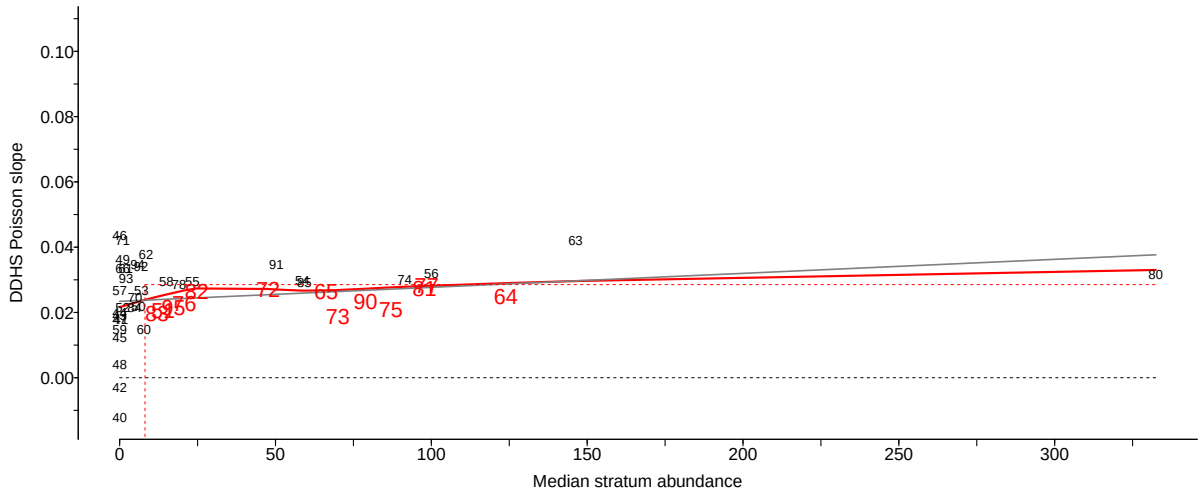


Figure 7.2F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Haddock.

7.3 White hake (Merluche blanche) - species code 12 (category LF)

Scientific name: Urophycis tenuis

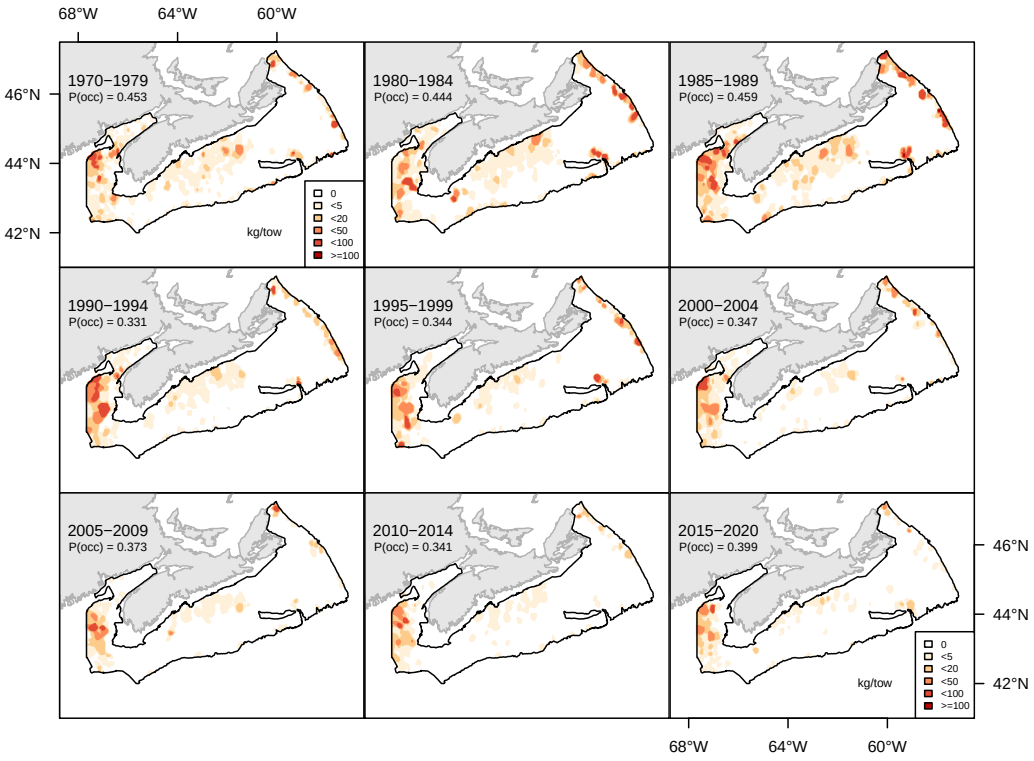


Figure 7.3A. Inverse distance weighted distribution of catch biomass (kg/tow) for White hake.

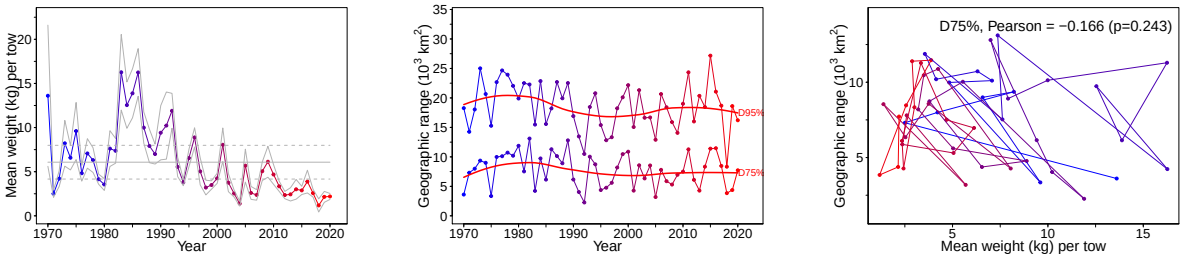


Figure 7.3B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of White hake.

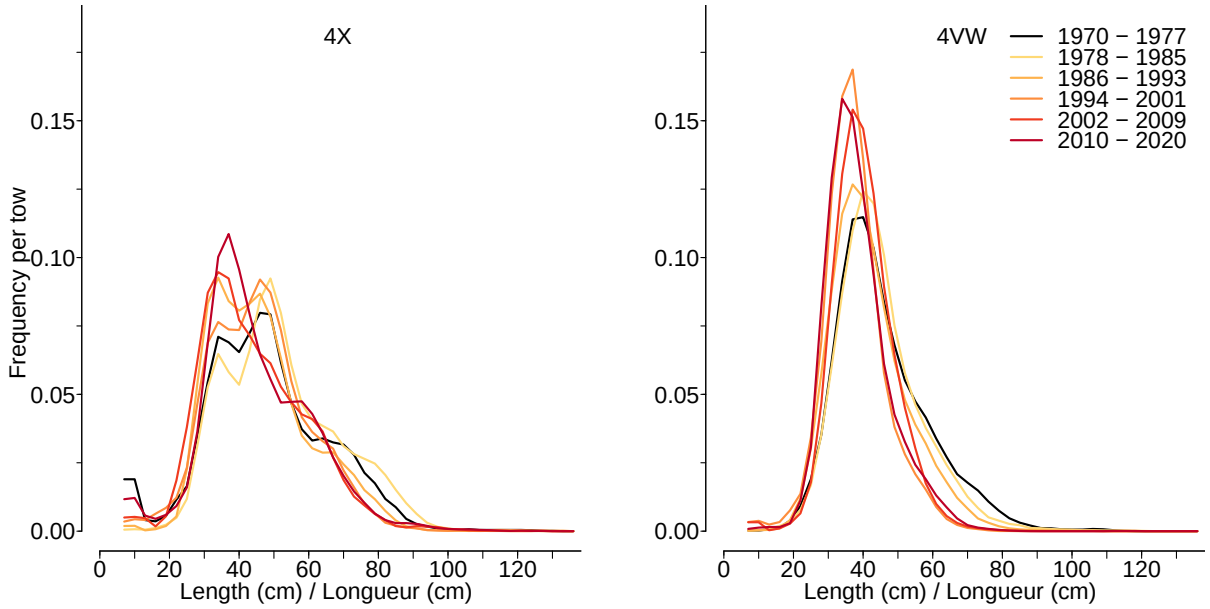


Figure 7.3C. Length frequency distribution in NAFO units 4X and 4VW for White hake.

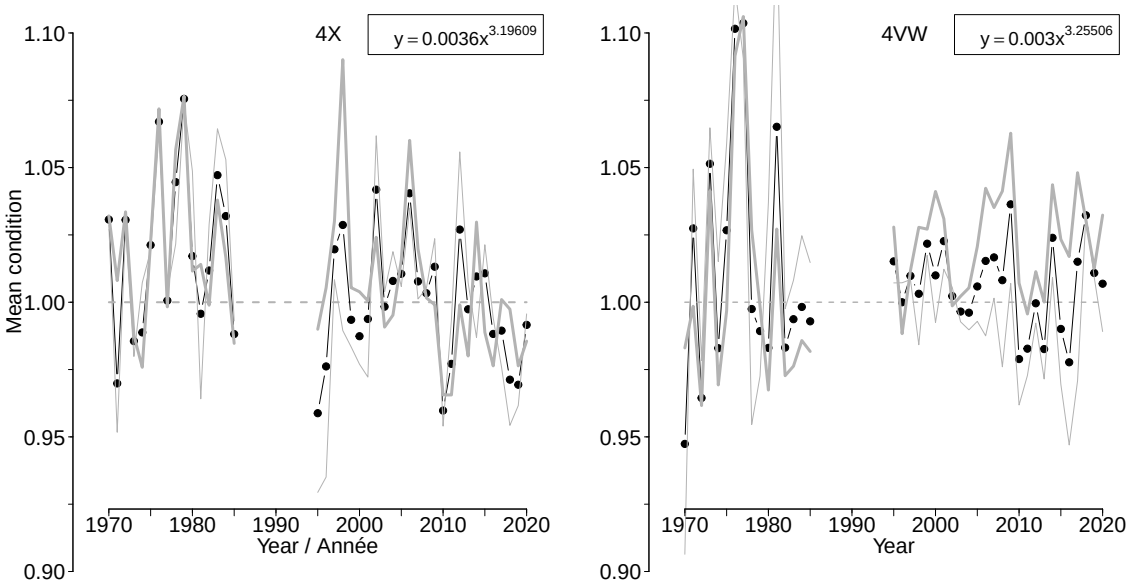
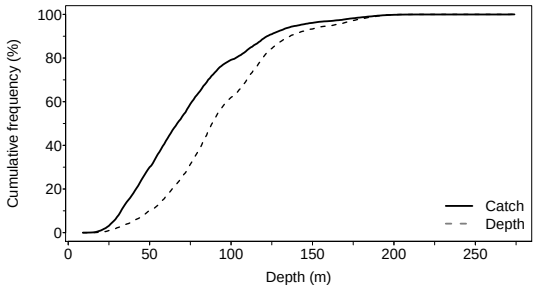
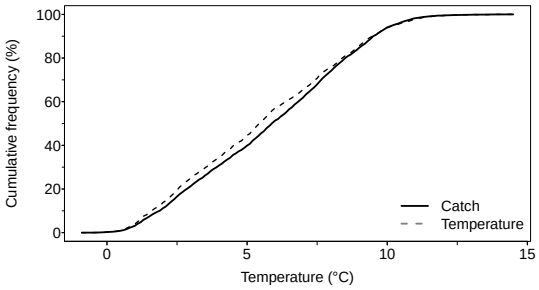


Figure 7.3D. Average fish condition in NAFO units 4X and 4VW for White hake.





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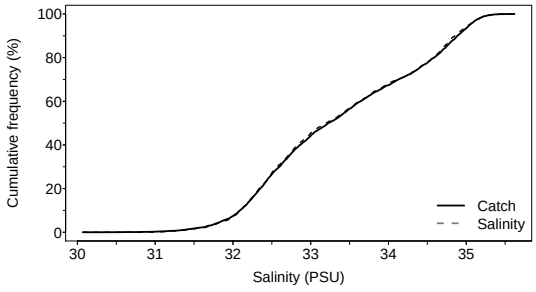
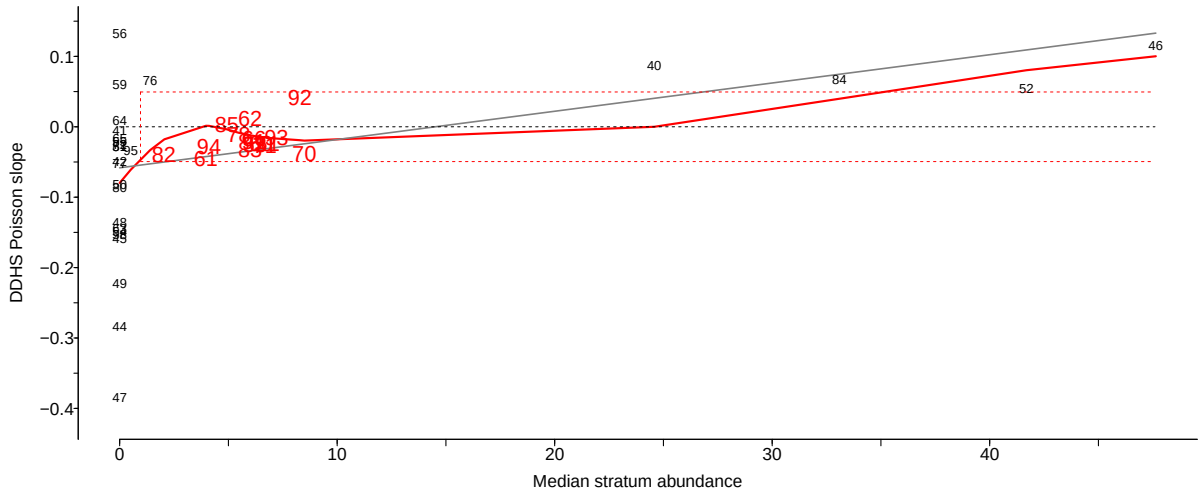


Freq	Depth	Temp	Sal
F5	40	1.1	31.00
F25	70	3.0	32.46
F50	89	5.5	33.20
F75	115	7.9	34.39
F95	163	10.0	35.04

Figure 7.3E. Catch distribution by depth, temperature and salinity of White hake.



722

Figure 7.3F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for White hake.

7.4 Red hake (Merluche écureuil) - species code 13 (category LF)

Scientific name: Urophycis chuss

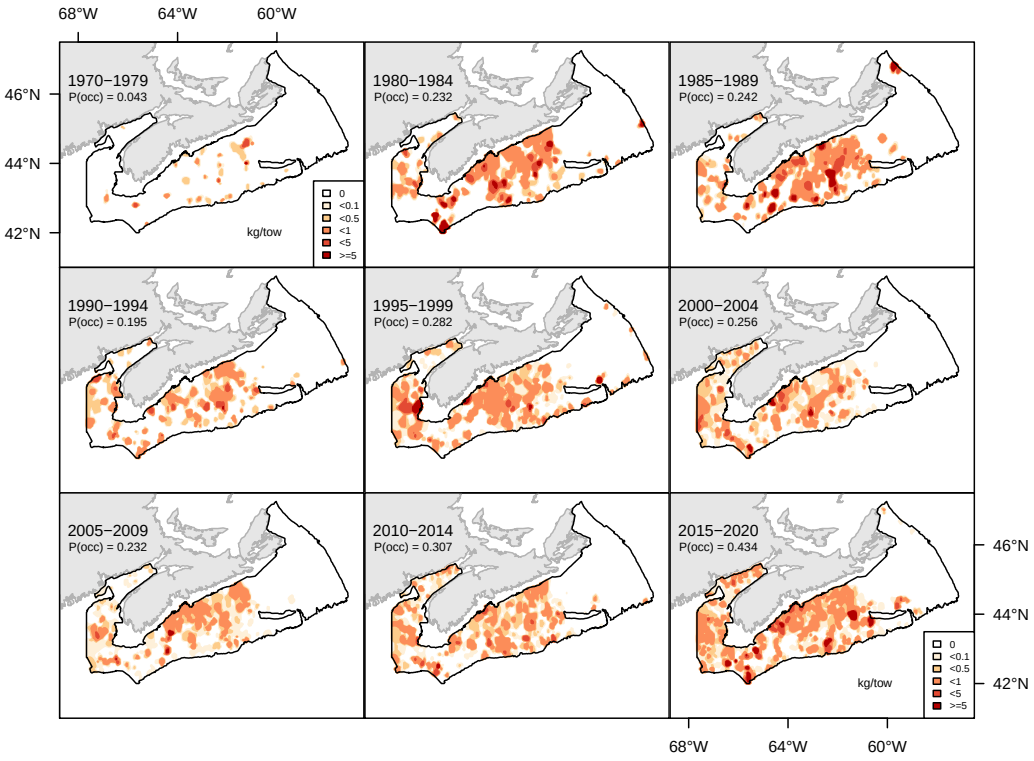


Figure 7.4A. Inverse distance weighted distribution of catch biomass (kg/tow) for Red hake.

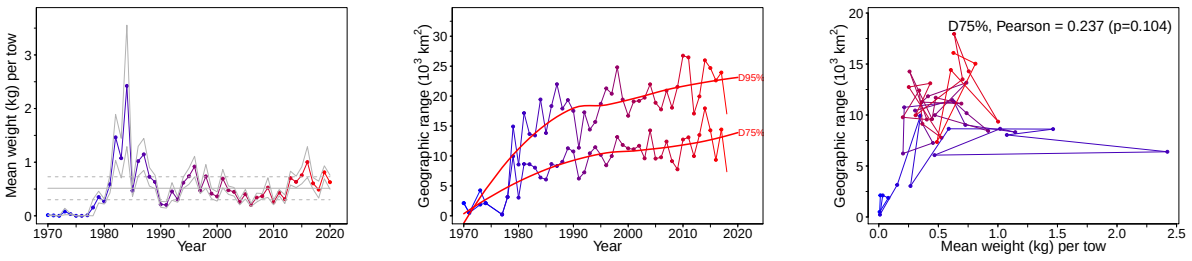


Figure 7.4B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Red hake.

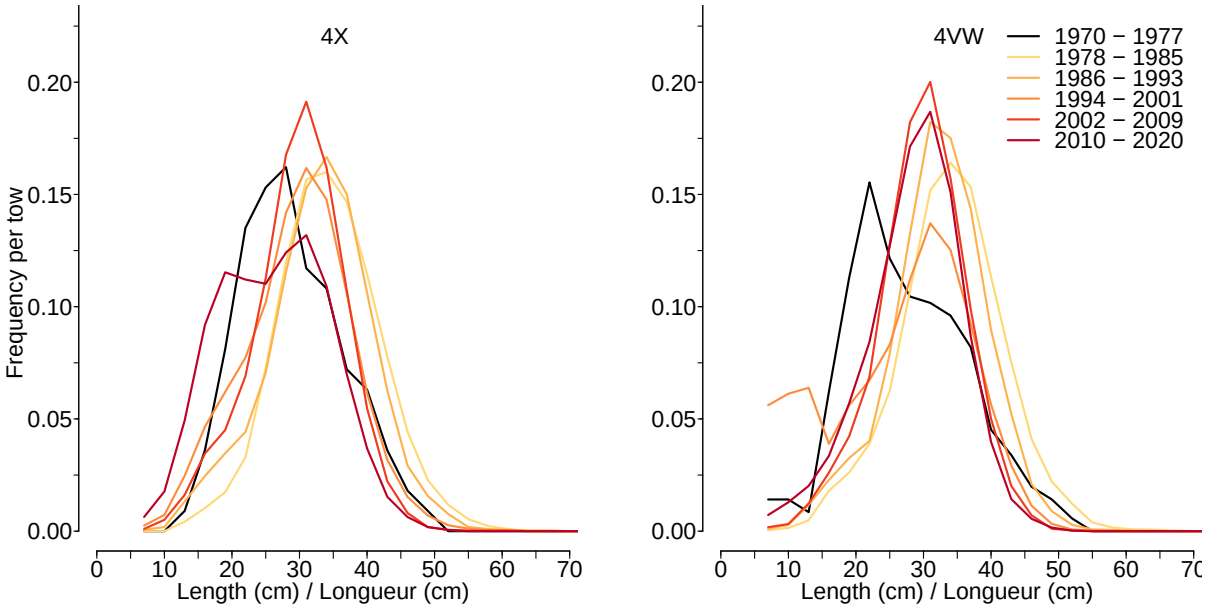


Figure 7.4C. Length frequency distribution in NAFO units 4X and 4VW for Red hake.

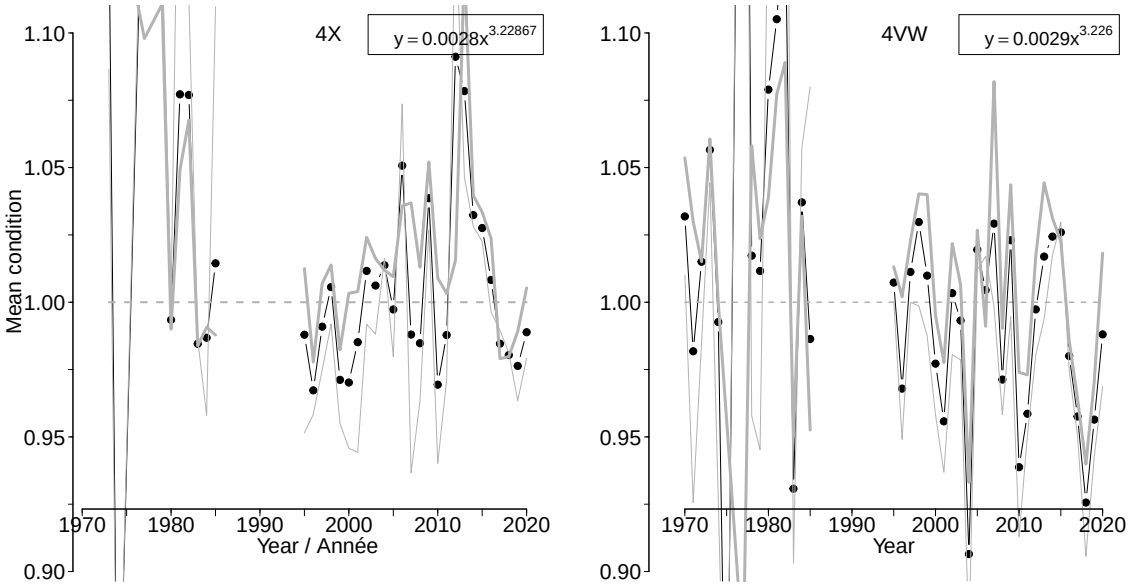
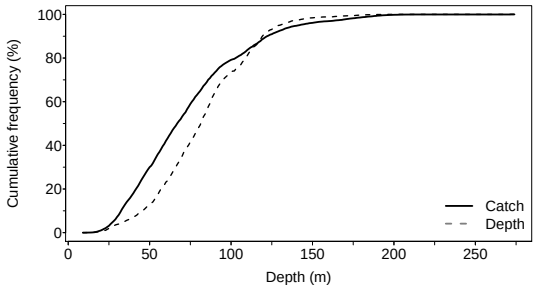
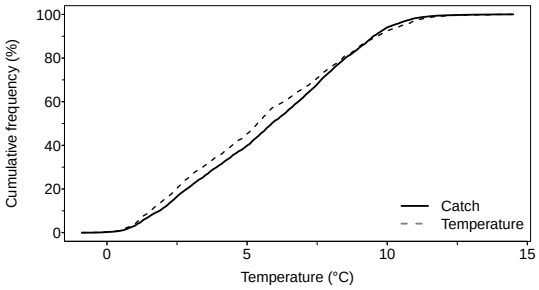
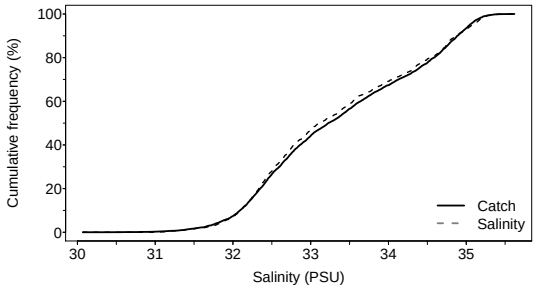


Figure 7.4D. Average fish condition in NAFO units 4X and 4VW for Red hake.



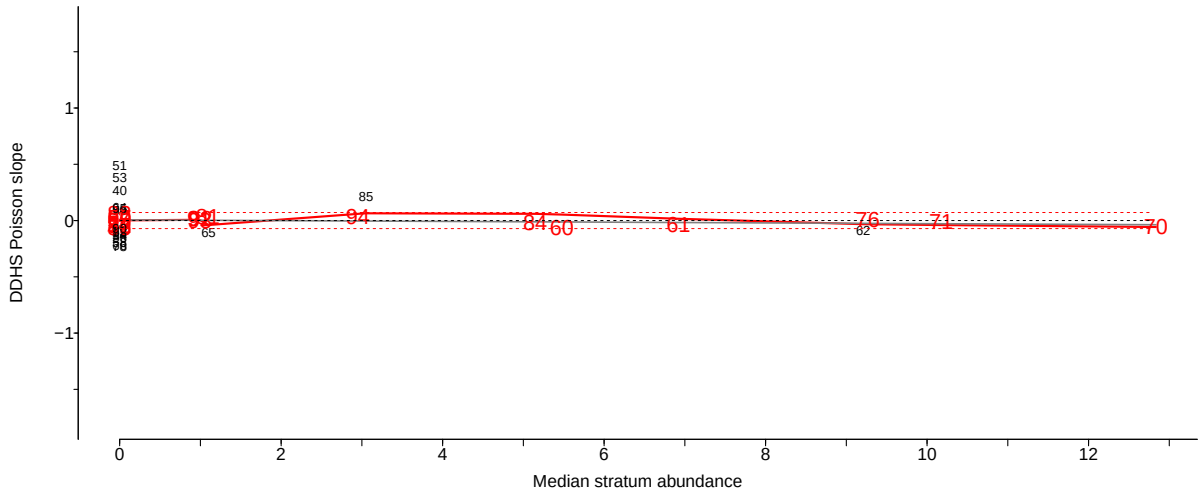


729



Freq	Depth	Temp	Sal
F5	35	1.1	31.00
F25	62	2.9	32.43
F50	82	5.4	33.12
F75	103	7.9	34.32
F95	130	10.0	35.08

Figure 7.4E. Catch distribution by depth, temperature and salinity of Red hake.



730

Figure 7.4F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Red hake.

7.5 Silver hake (Merlu argenté) - species code 14 (category LF)

Scientific name: Merluccius bilinearis

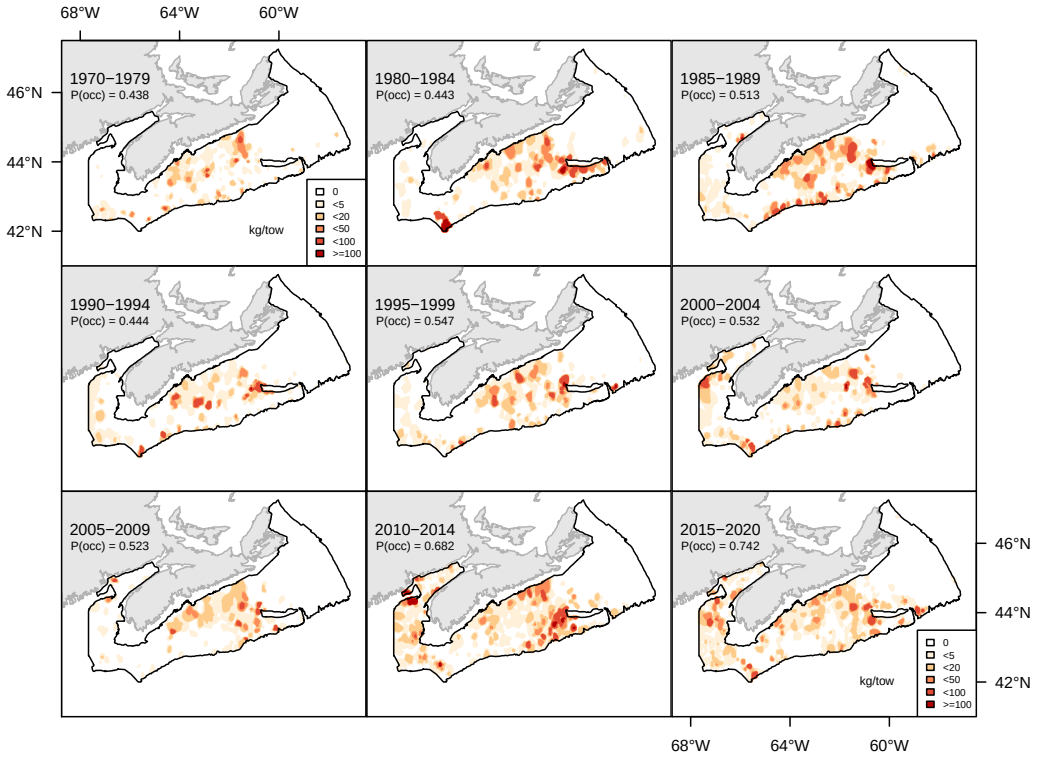


Figure 7.5A. Inverse distance weighted distribution of catch biomass (kg/tow) for Silver hake.

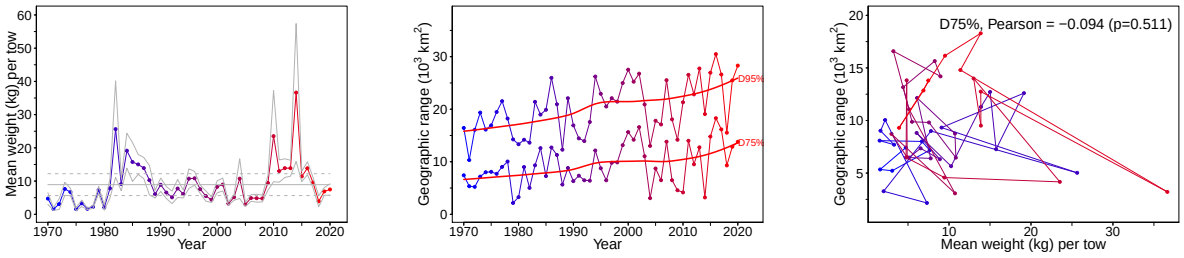


Figure 7.5B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Silver hake.

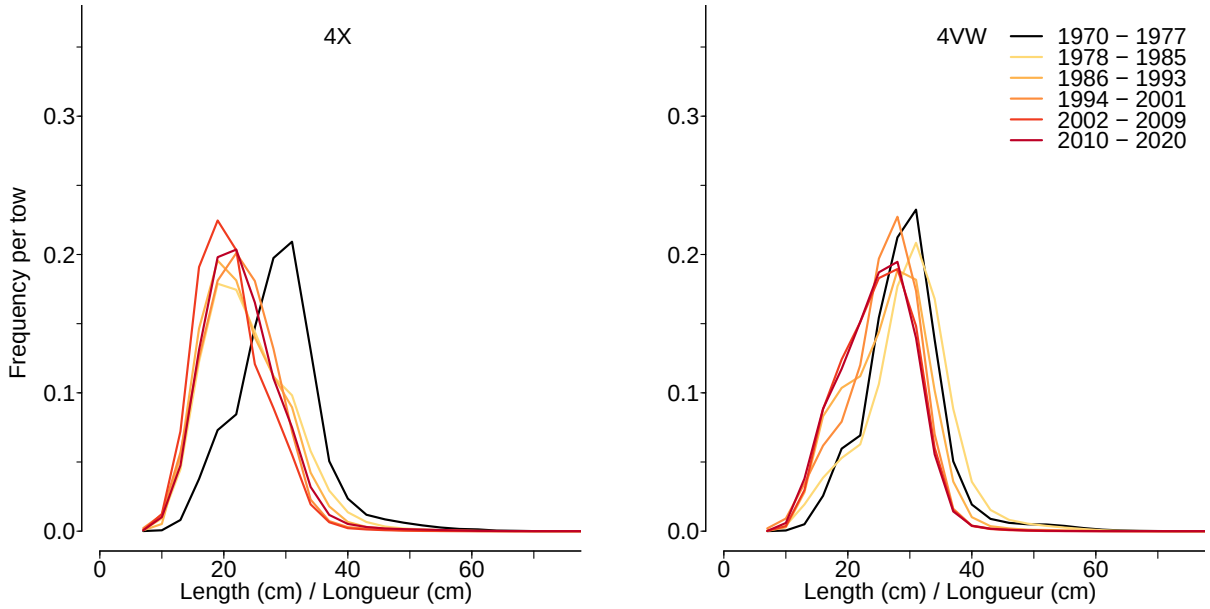


Figure 7.5C. Length frequency distribution in NAFO units 4X and 4VW for Silver hake.

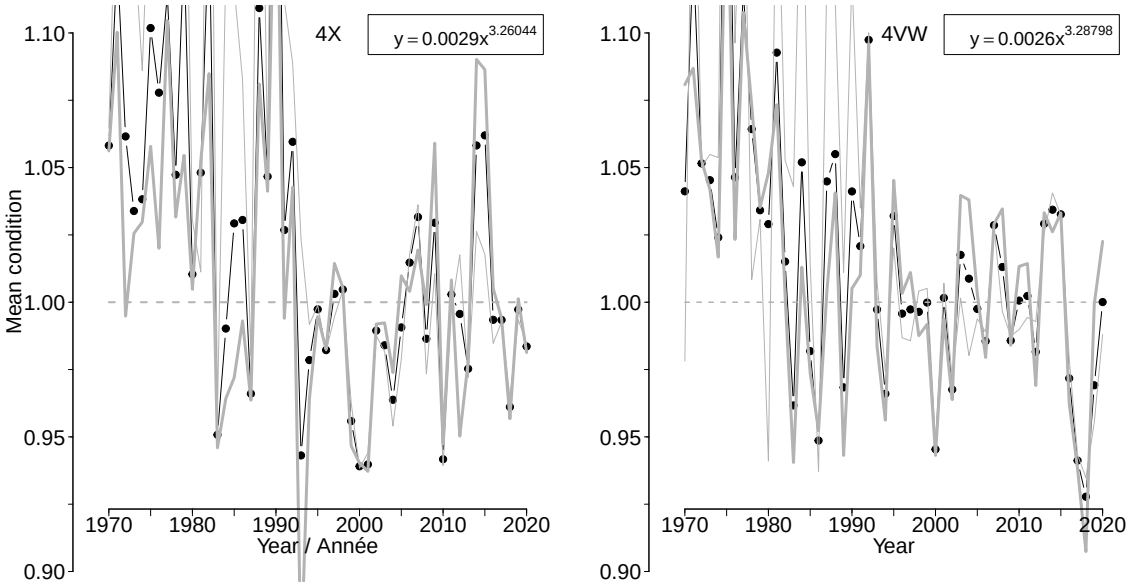
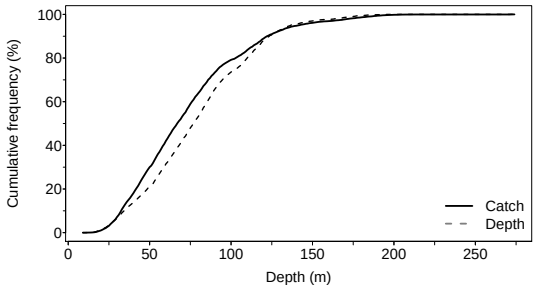
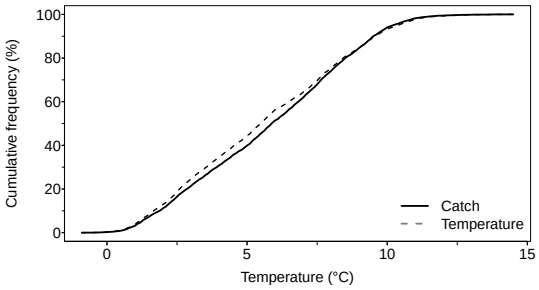
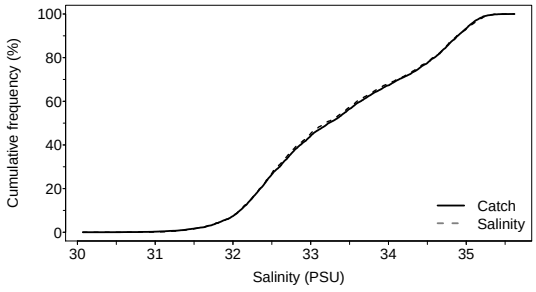


Figure 7.5D. Average fish condition in NAFO units 4X and 4VW for Silver hake.







Freq	Depth	Temp	Sal
F5	28	1.2	31.00
F25	55	3.1	32.46
F50	77	5.5	33.20
F75	104	8.0	34.37
F95	137	10.0	35.07

Figure 7.5E. Catch distribution by depth, temperature and salinity of Silver hake.

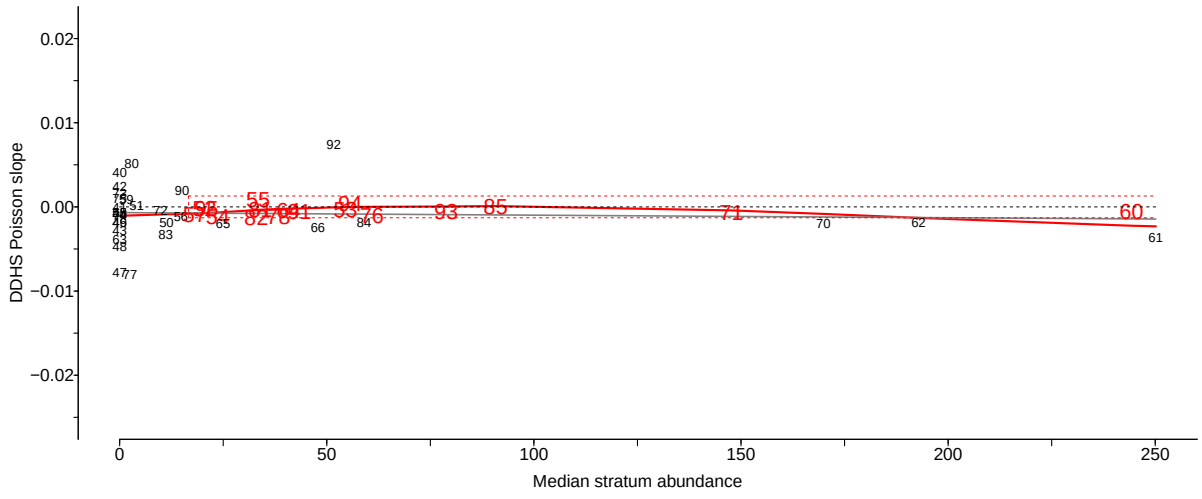


Figure 7.5F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Silver hake.

7.6 Pollock (Goberge) - species code 16 (category LF)

Scientific name: Pollachius virens

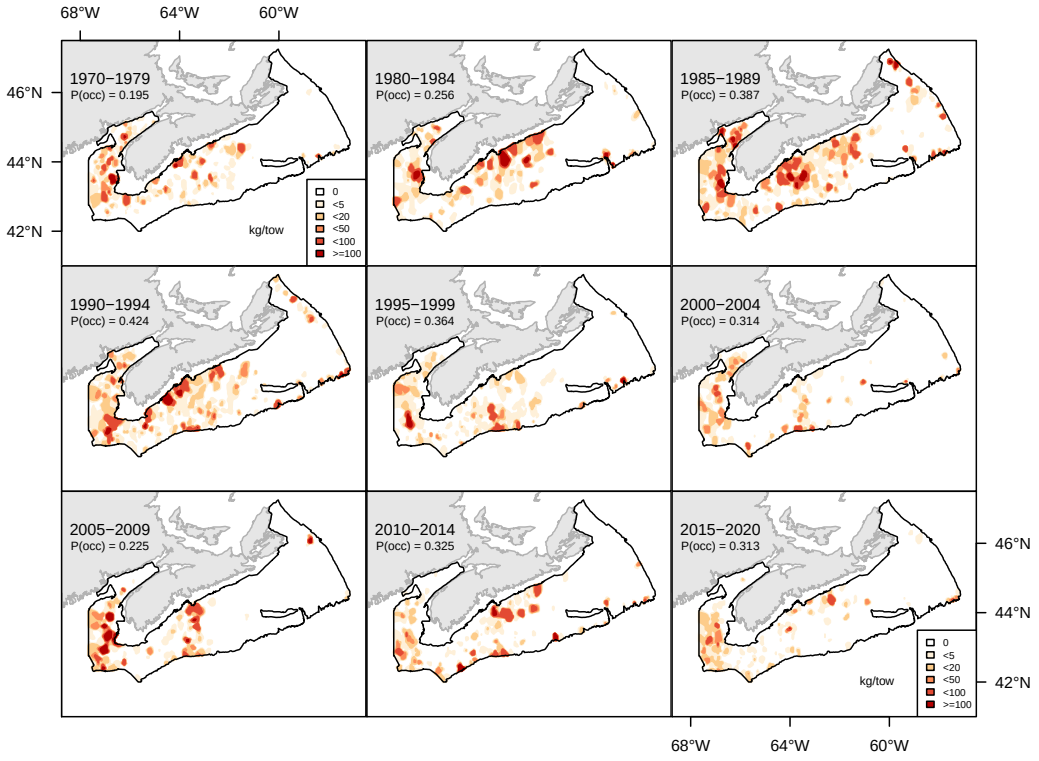


Figure 7.6A. Inverse distance weighted distribution of catch biomass (kg/tow) for Pollock.

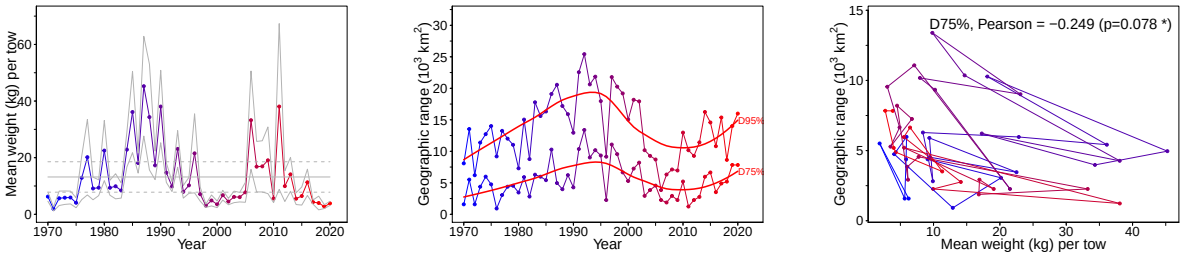


Figure 7.6B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Pollock.

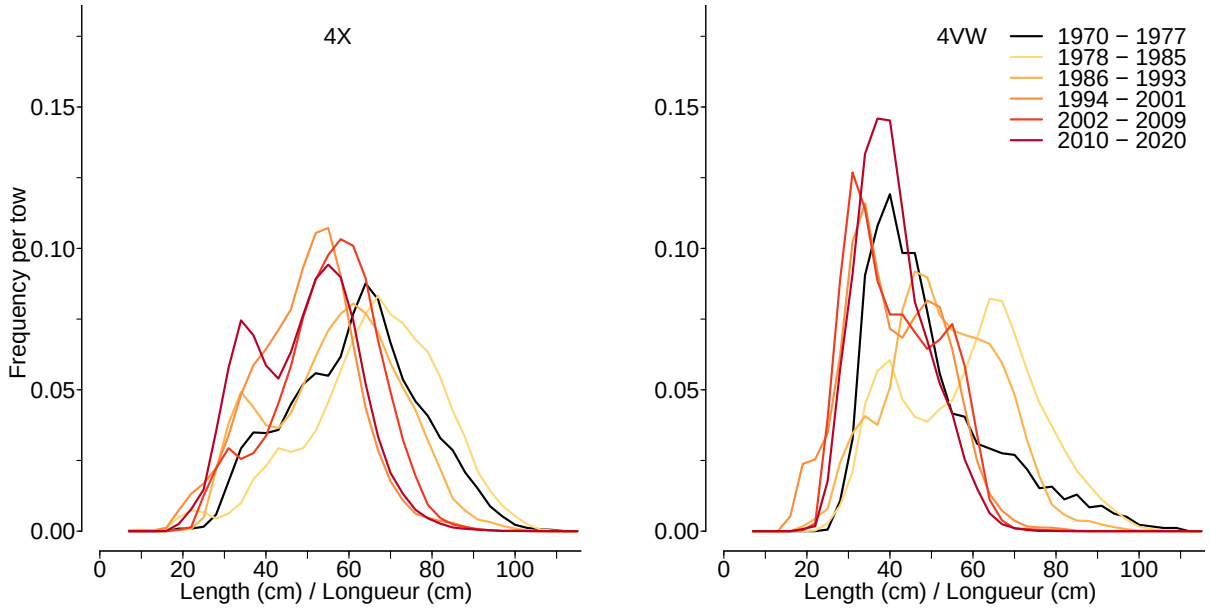


Figure 7.6C. Length frequency distribution in NAFO units 4X and 4VW for Pollock.

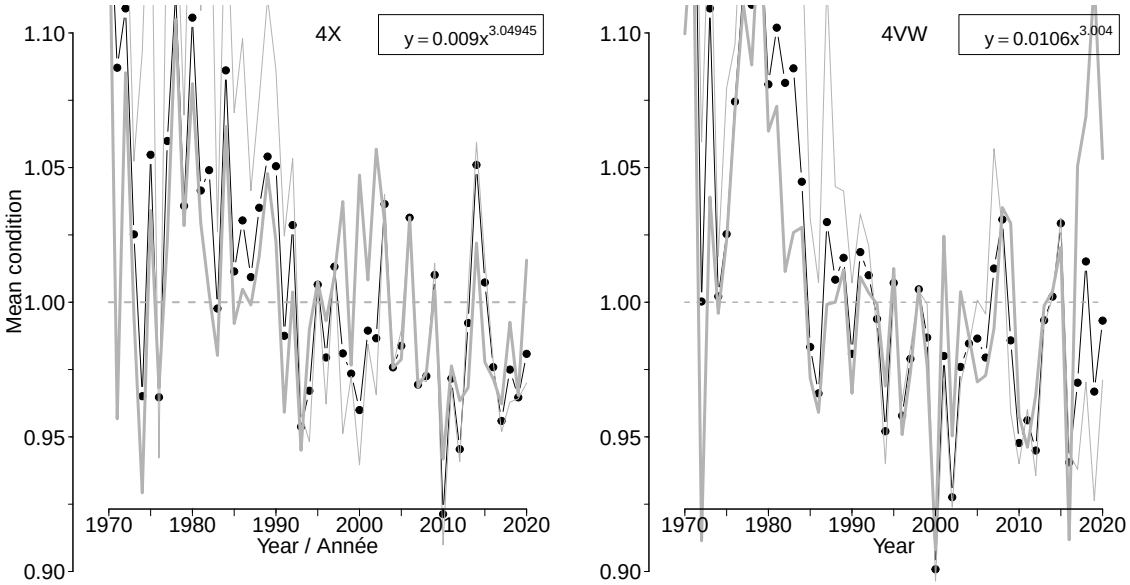
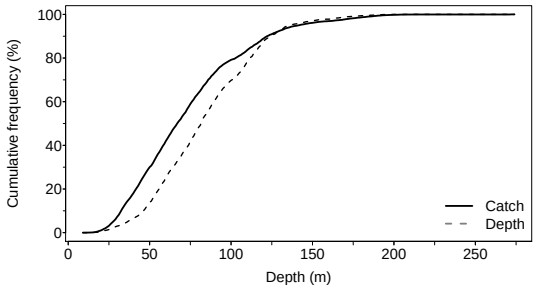
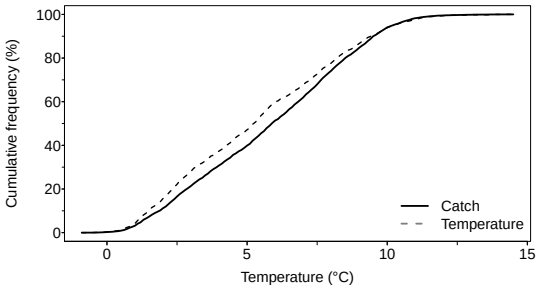
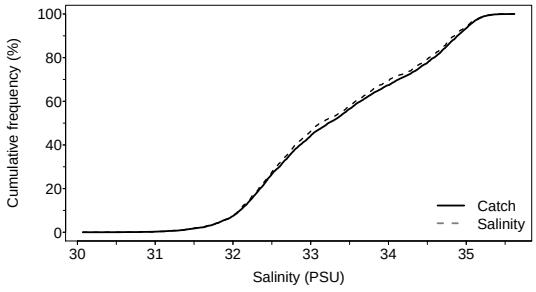


Figure 7.6D. Average fish condition in NAFO units 4X and 4VW for Pollock.







Freq	Depth	Temp	Sal
F5	37	1.1	31.00
F25	60	2.8	32.45
F50	82	5.3	33.14
F75	108	7.7	34.33
F95	137	10.0	35.03

Figure 7.6E. Catch distribution by depth, temperature and salinity of Pollock.

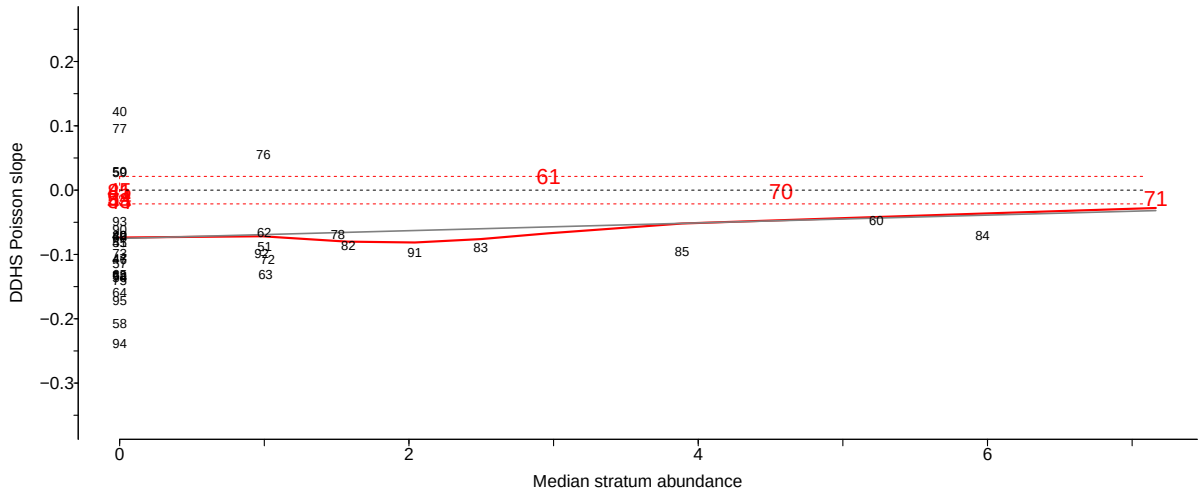


Figure 7.6F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Pollock.

7.7 Atlantic redfishes (Sébastes de l'Atlantique) - species code 23 (category LF)

Scientific name: Sebastes

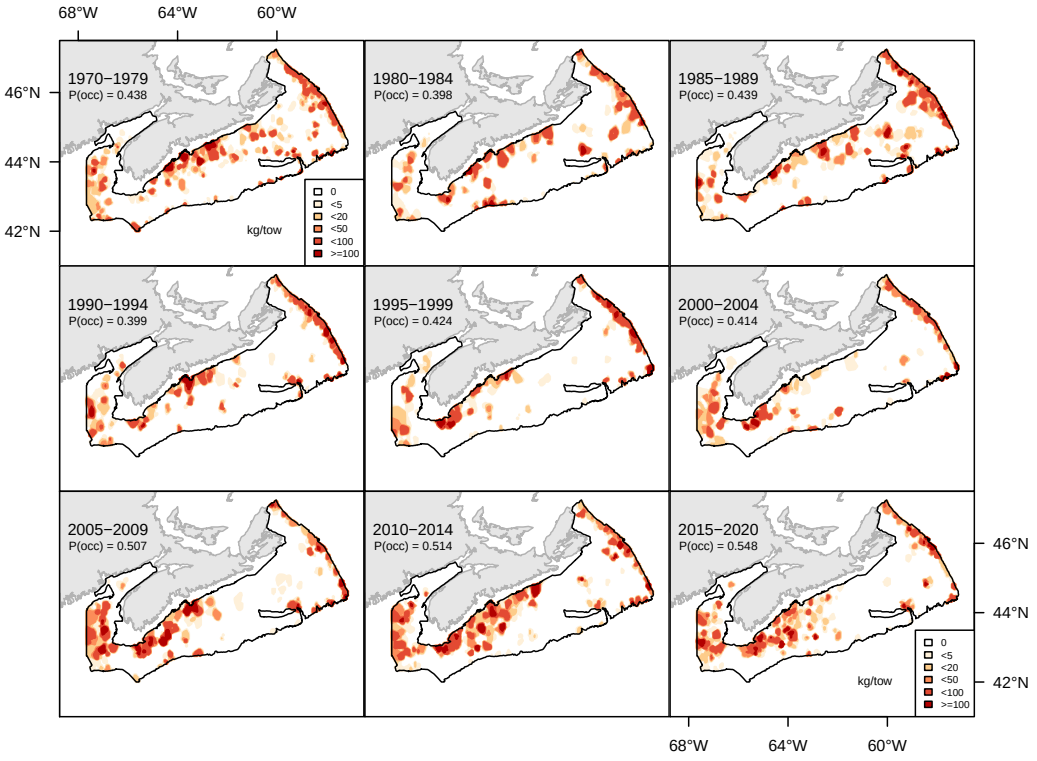


Figure 7.7A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic redfishes.

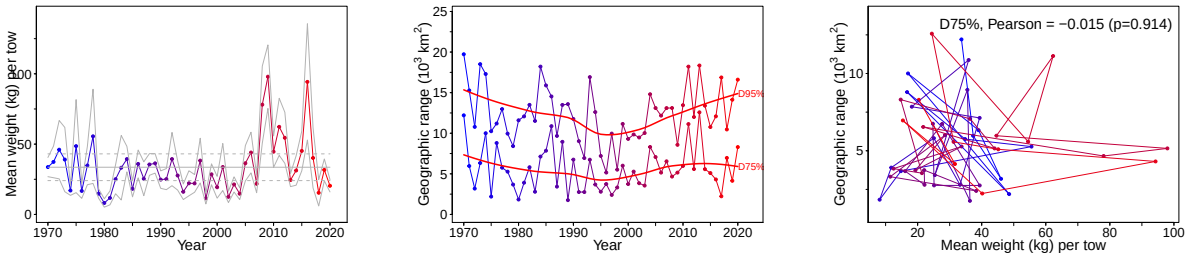


Figure 7.7B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic redfishes.

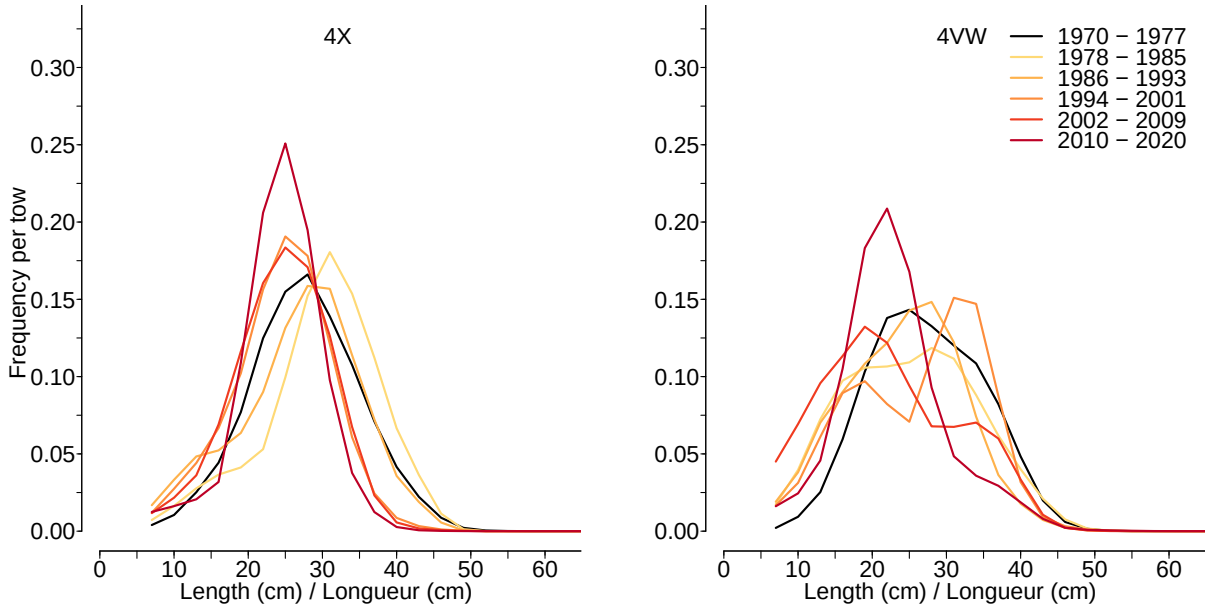


Figure 7.7C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic redfishes.

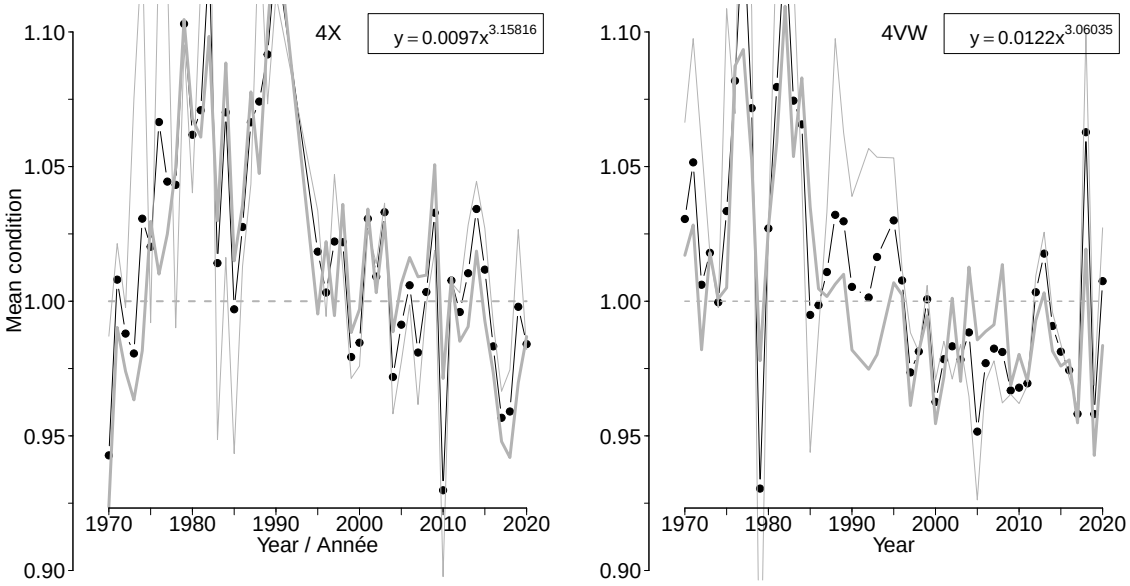
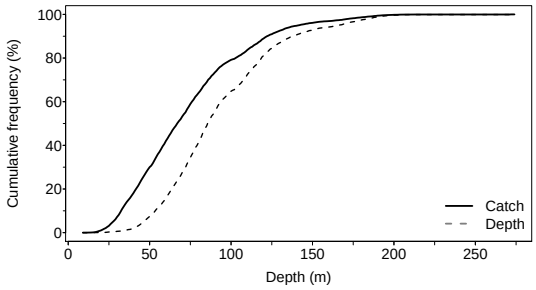
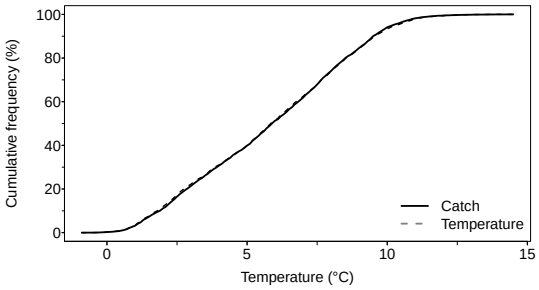
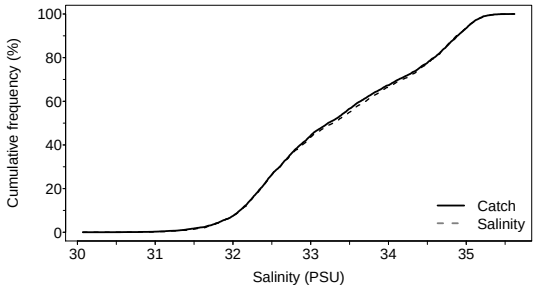


Figure 7.7D. Average fish condition in NAFO units 4X and 4VW for Atlantic redfishes.





753



Freq	Depth	Temp	Sal
F5	47	1.2	31.00
F25	68	3.4	32.48
F50	86	5.9	33.29
F75	114	8.1	34.41
F95	166	10.0	35.05

Figure 7.7E. Catch distribution by depth, temperature and salinity of Atlantic redfishes.

754

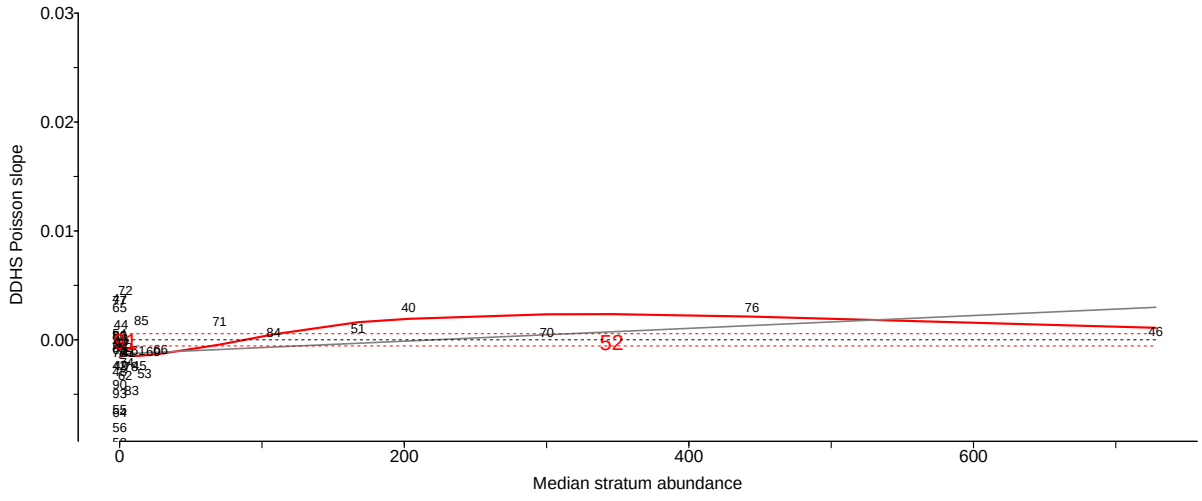


Figure 7.7F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic redfishes.

7.8 Atlantic halibut (Flétan de l'Atlantique) - species code 30 (category LF)

Scientific name: Hippoglossus hippoglossus

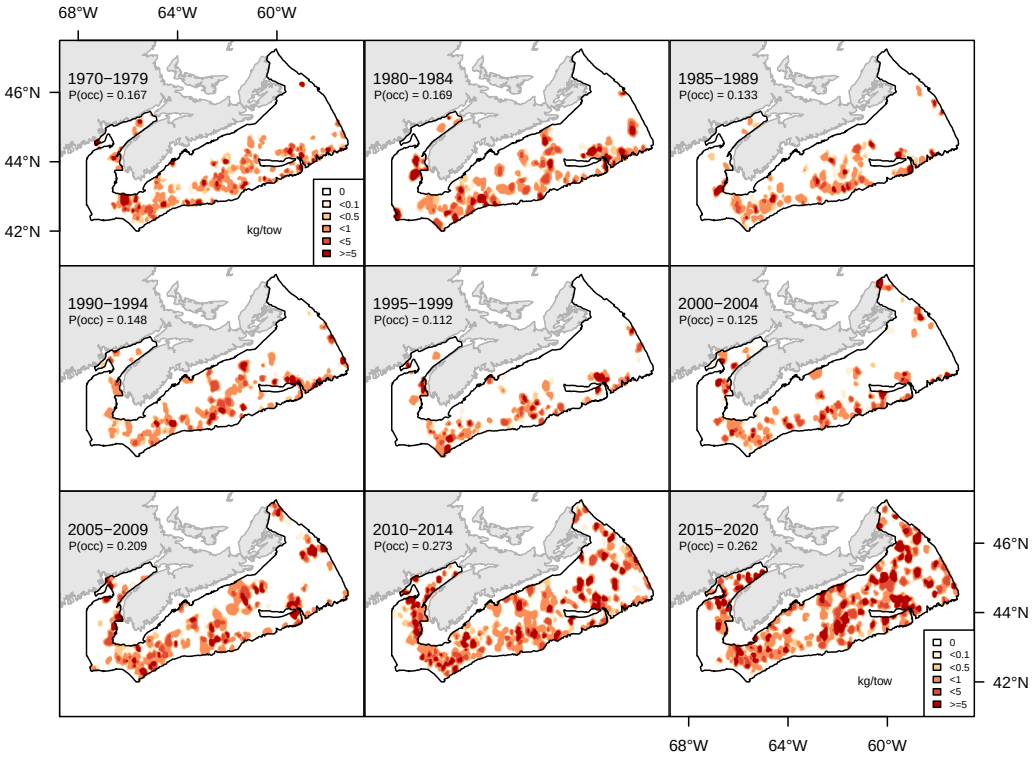


Figure 7.8A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic halibut.

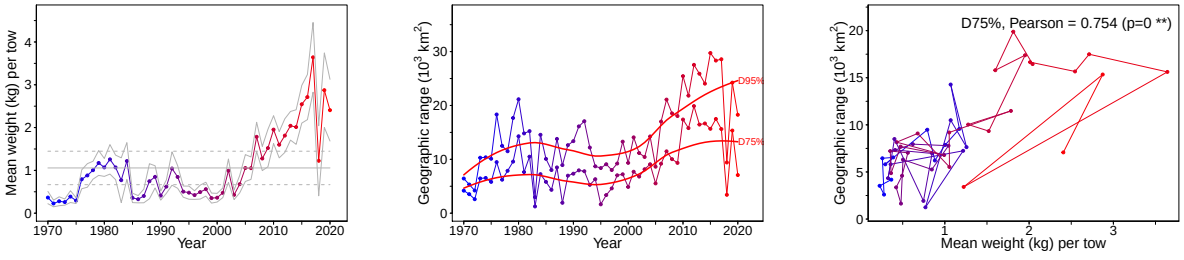


Figure 7.8B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic halibut.

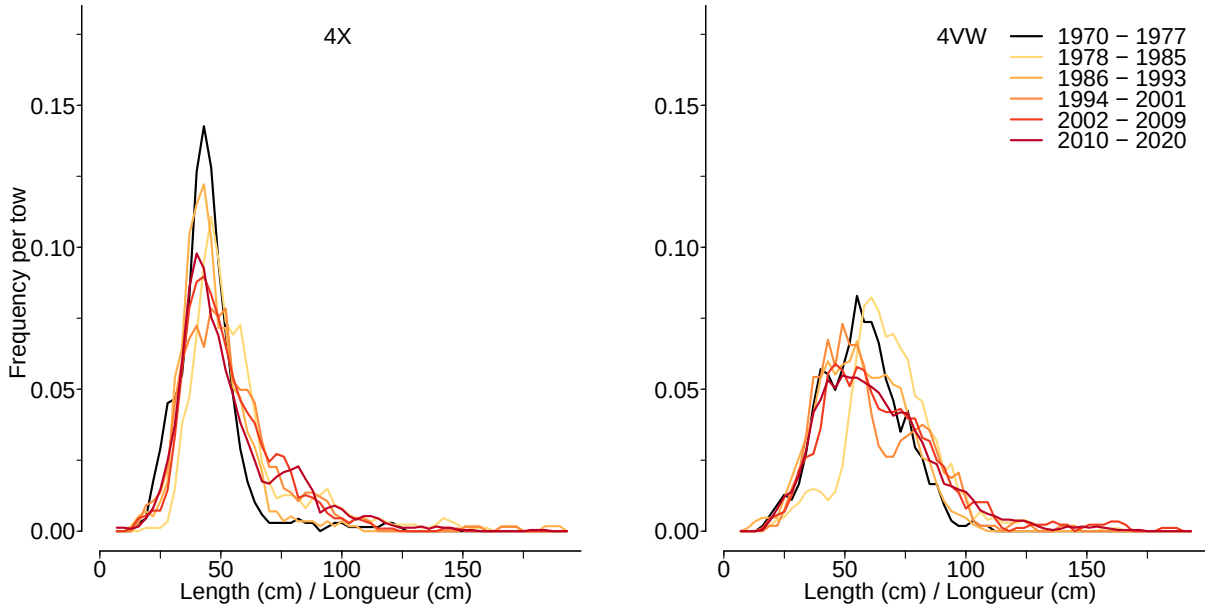


Figure 7.8C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic halibut.

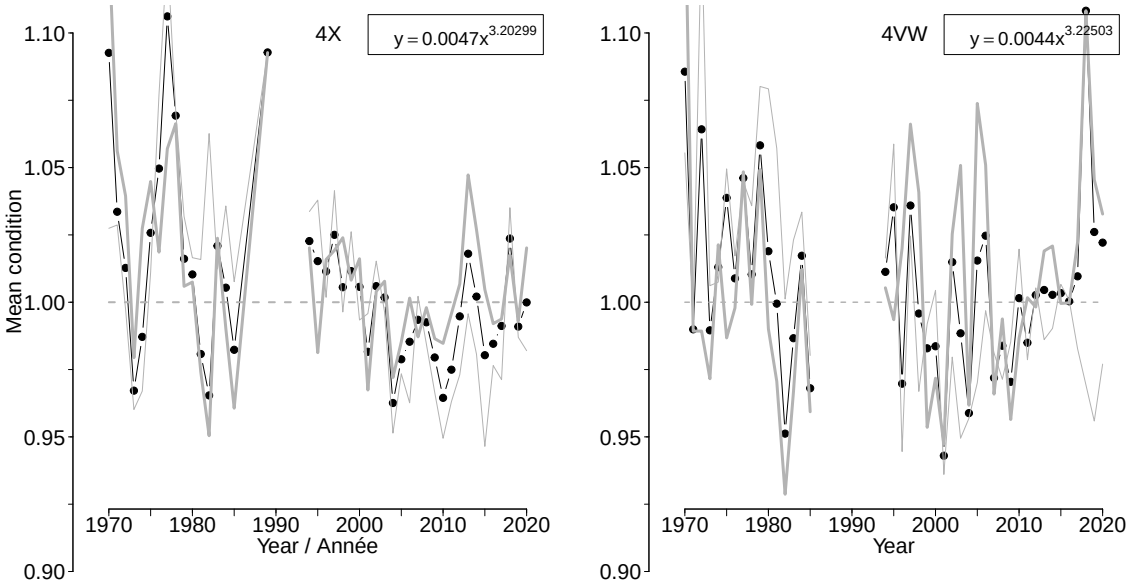
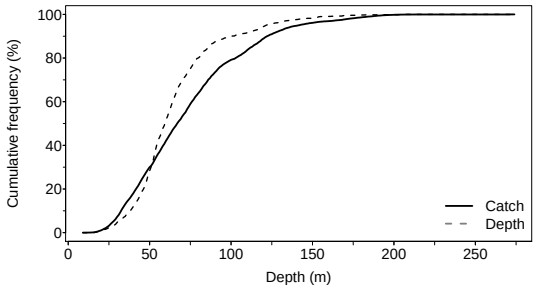
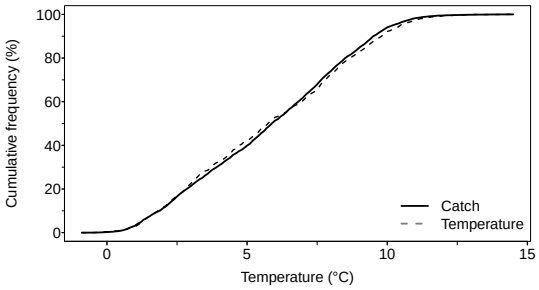
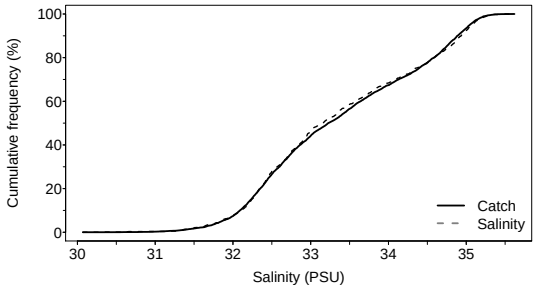


Figure 7.8D. Average fish condition in NAFO units 4X and 4VW for Atlantic halibut.







Freq	Depth	Temp	Sal
F5	31	1.3	31.00
F25	49	3.2	32.45
F50	60	5.8	33.16
F75	75	8.3	34.34
F95	122	10.0	35.08

Figure 7.8E. Catch distribution by depth, temperature and salinity of Atlantic halibut.

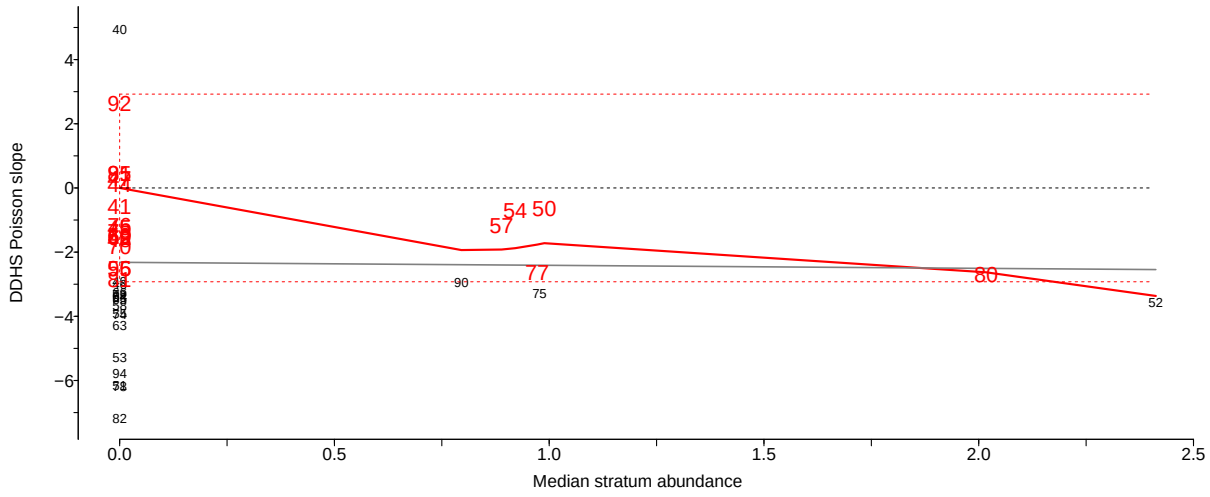


Figure 7.8F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic halibut.

7.9 American plaice (Plie canadienne) - species code 40 (category LF)

Scientific name: Hippoglossoides platessoides

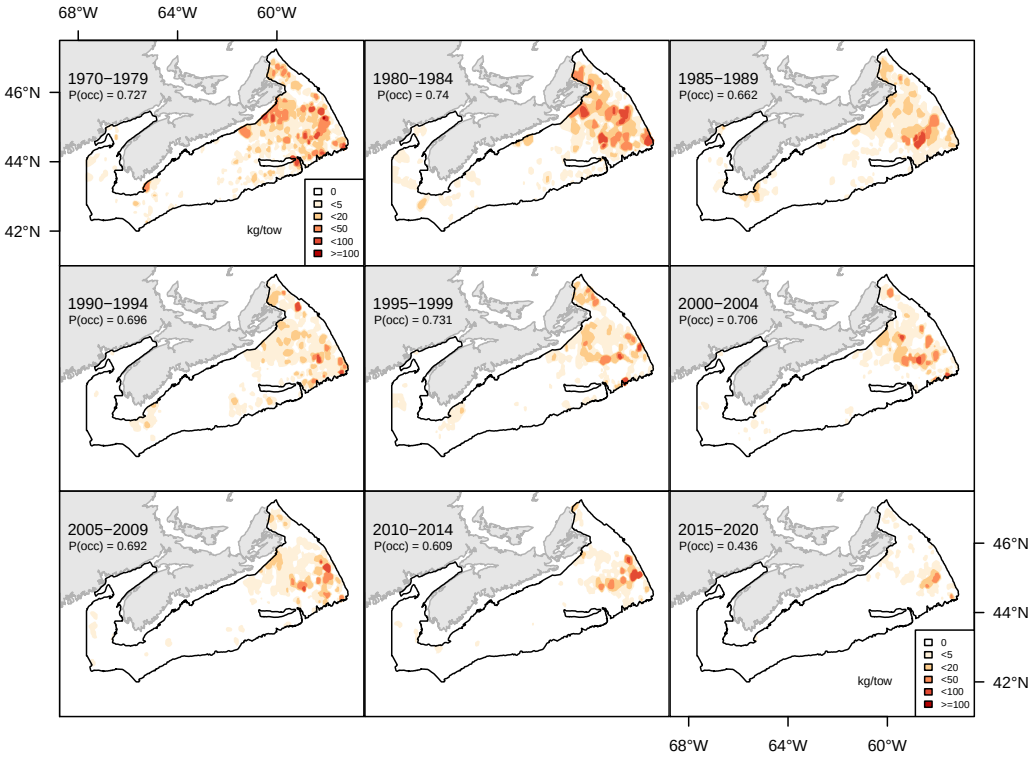


Figure 7.9A. Inverse distance weighted distribution of catch biomass (kg/tow) for American plaice.

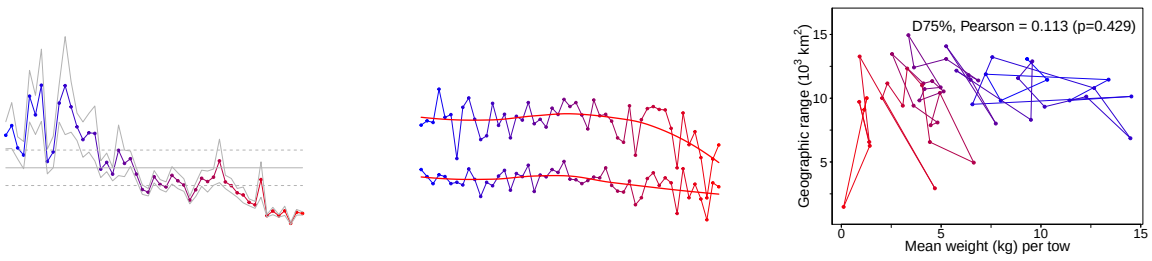


Figure 7.9B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American plaice.

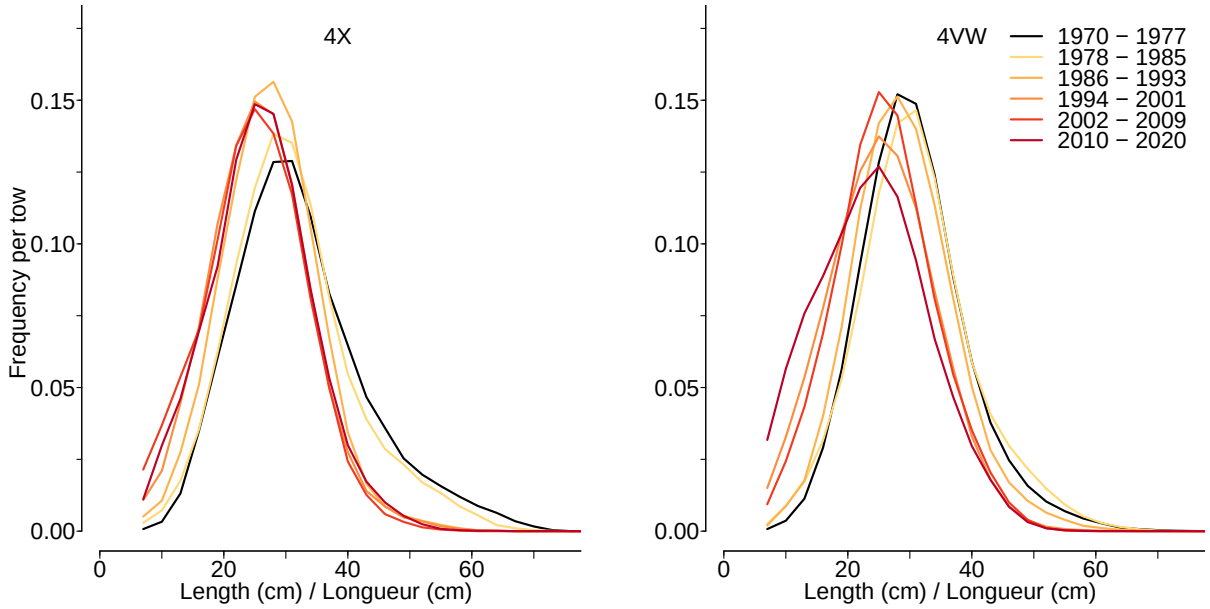


Figure 7.9C. Length frequency distribution in NAFO units 4X and 4VW for American plaice.

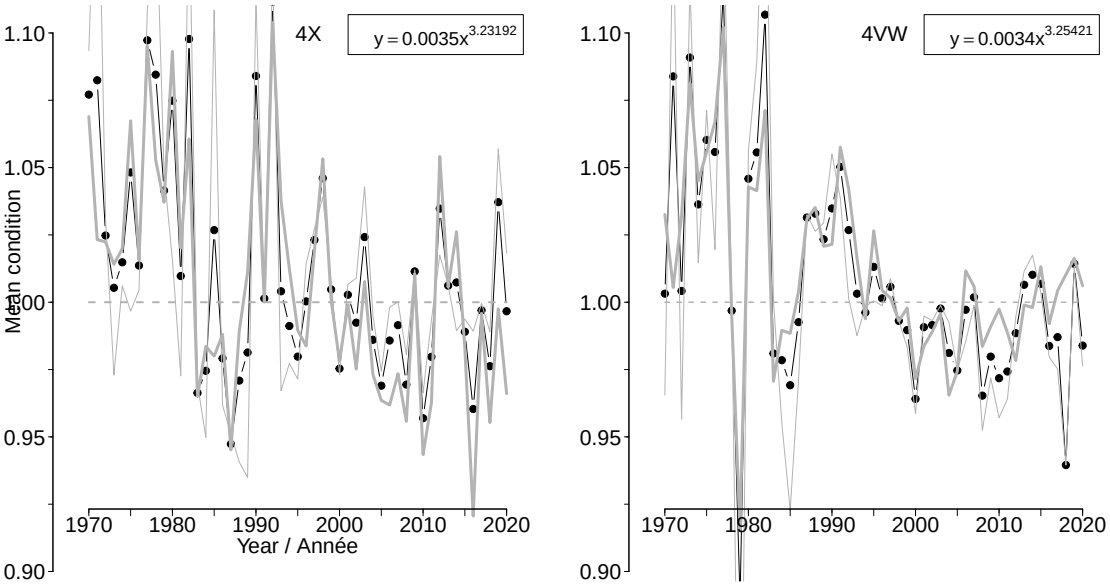
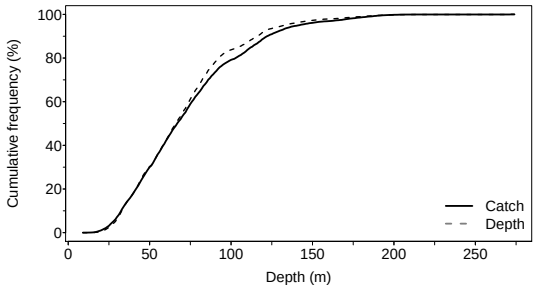
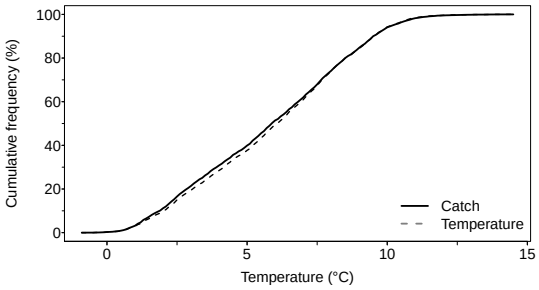
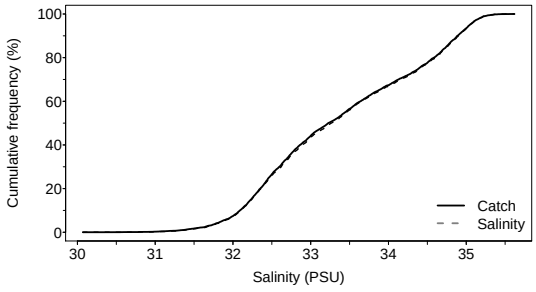


Figure 7.9D. Average fish condition in NAFO units 4X and 4VW for American plaice.







Freq	Depth	Temp	Sal
F5	29	1.3	31.00
F25	46	3.7	32.48
F50	67	6.1	33.27
F75	87	8.1	34.41
F95	133	10.0	35.05

Figure 7.9E. Catch distribution by depth, temperature and salinity of American plaice.

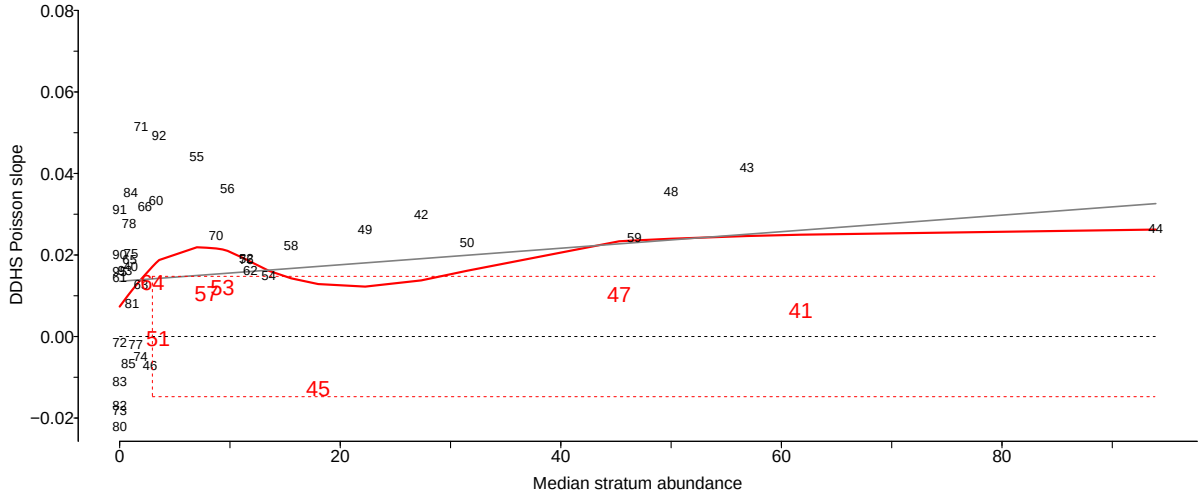


Figure 7.9F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for American plaice.

7.10 Witch flounder (Plie grise) - species code 41 (category LF)

Scientific name: Glyptocephalus cynoglossus

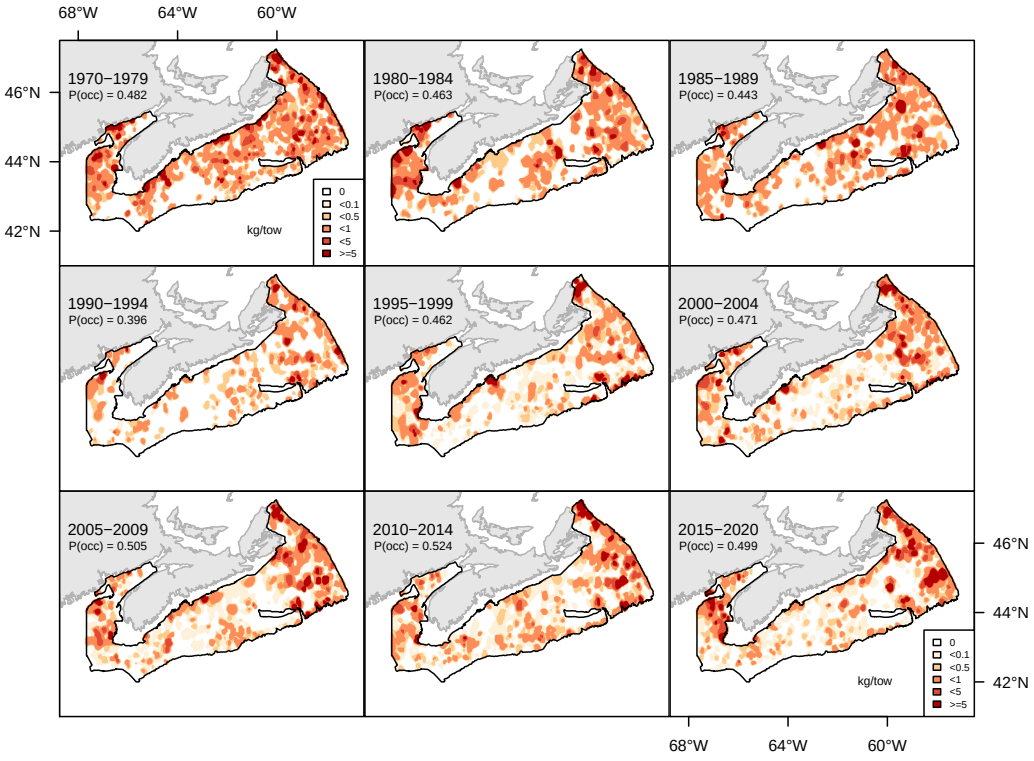


Figure 7.10A. Inverse distance weighted distribution of catch biomass (kg/tow) for Witch flounder.

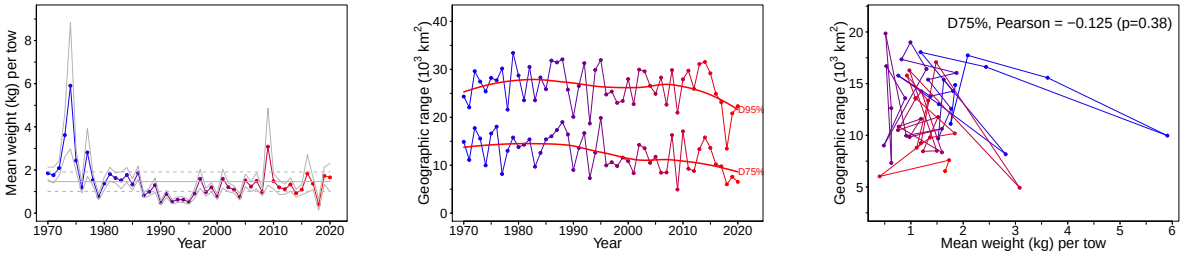


Figure 7.10B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Witch flounder.

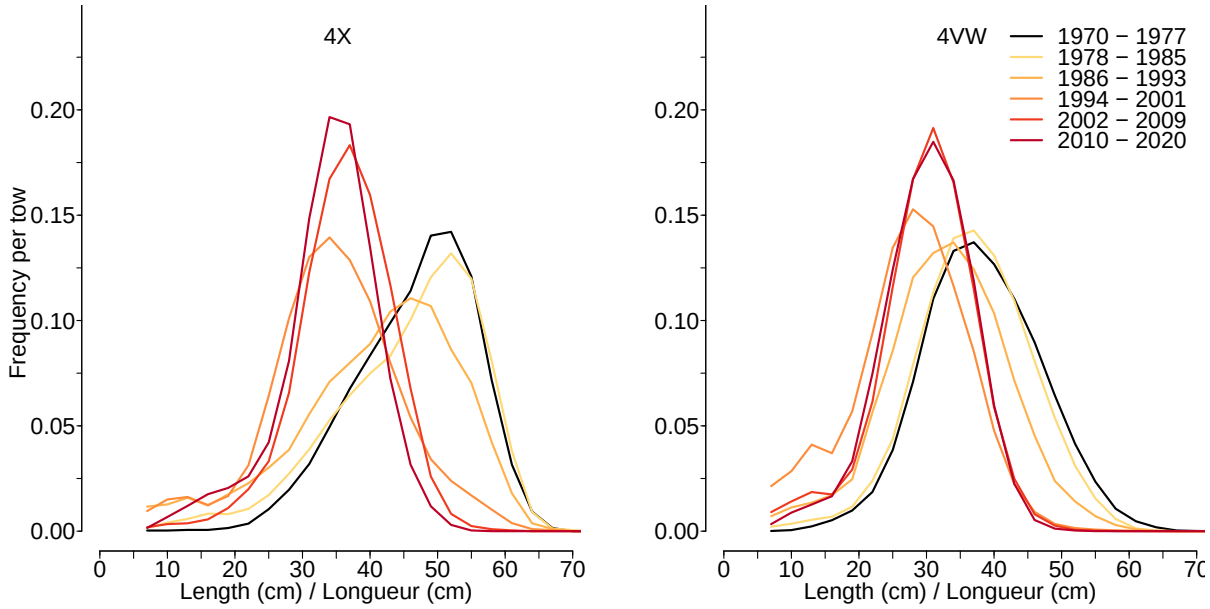


Figure 7.10C. Length frequency distribution in NAFO units 4X and 4VW for Witch flounder.

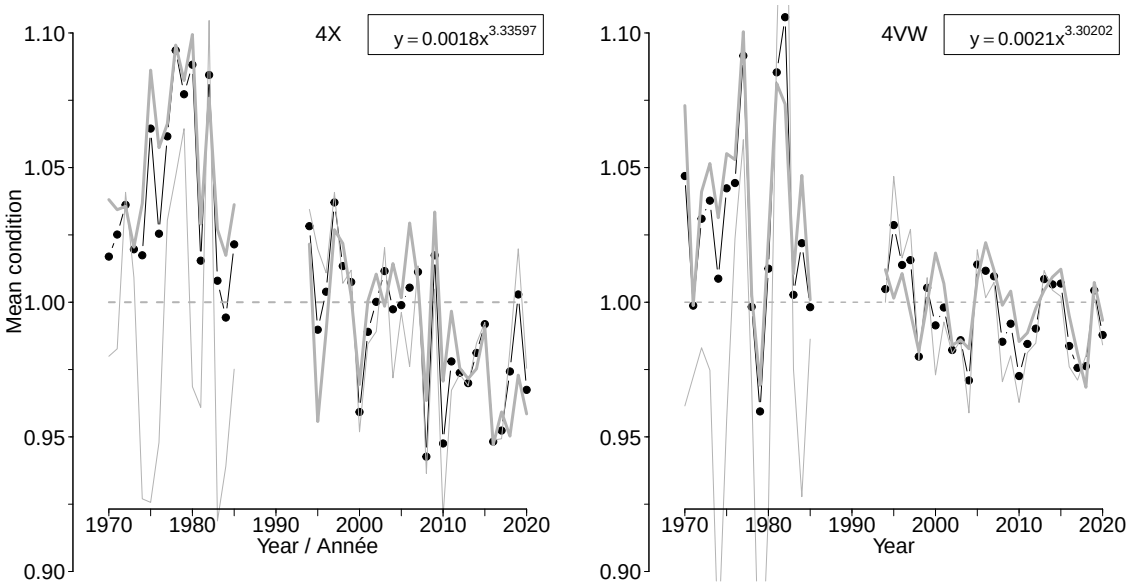
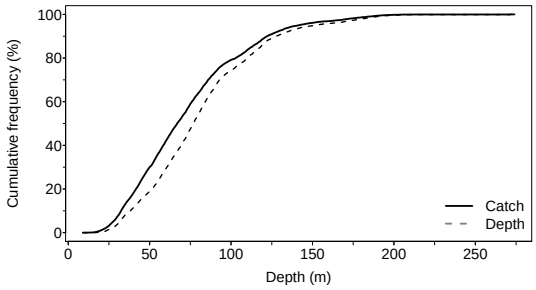
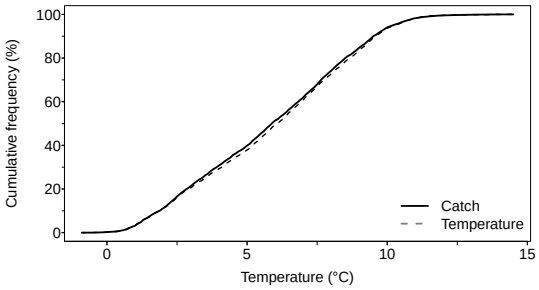
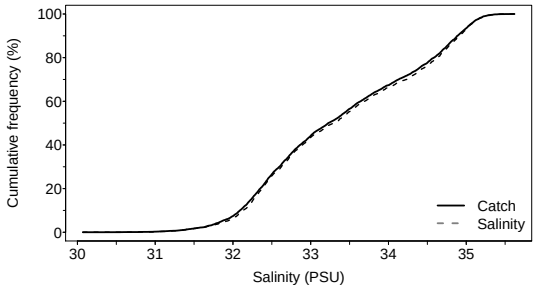


Figure 7.10D. Average fish condition in NAFO units 4X and 4VW for Witch flounder.



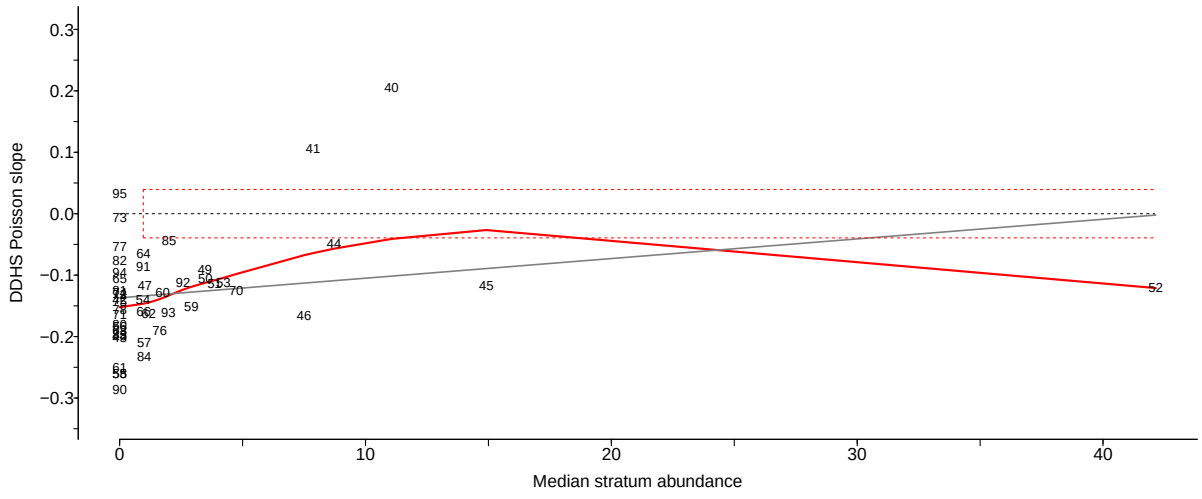


777



Freq	Depth	Temp	Sal
F5	32	1.3	31.00
F25	57	3.5	32.49
F50	77	6.1	33.30
F75	102	8.2	34.45
F95	152	10.0	35.06

Figure 7.10E. Catch distribution by depth, temperature and salinity of Witch flounder.



778

Figure 7.10F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Witch flounder.

7.11 Yellowtail flounder (Limande à queue jaune) - species code 42 (category LF)

Scientific name: Limanda ferruginea

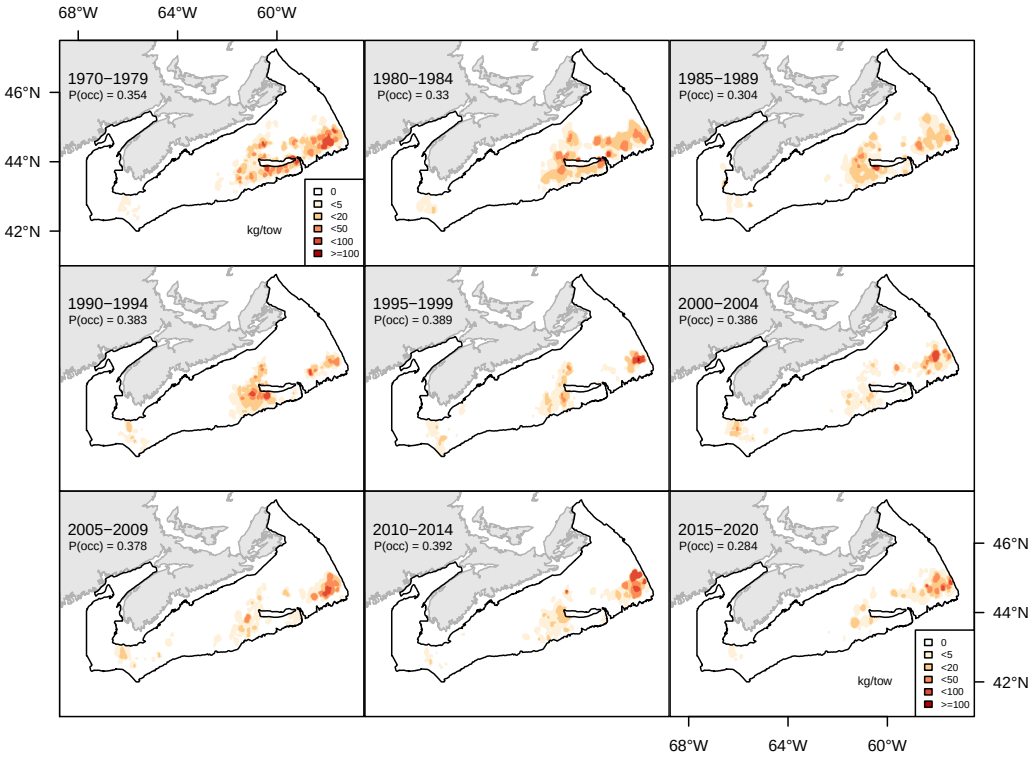


Figure 7.11A. Inverse distance weighted distribution of catch biomass (kg/tow) for Yellowtail flounder.

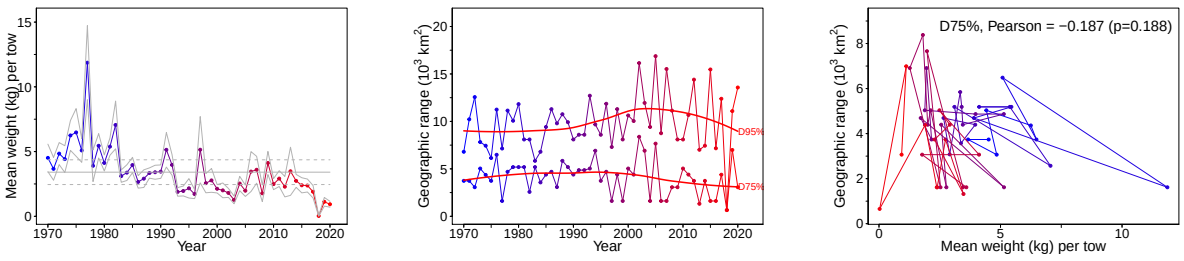


Figure 7.11B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Yellowtail flounder.

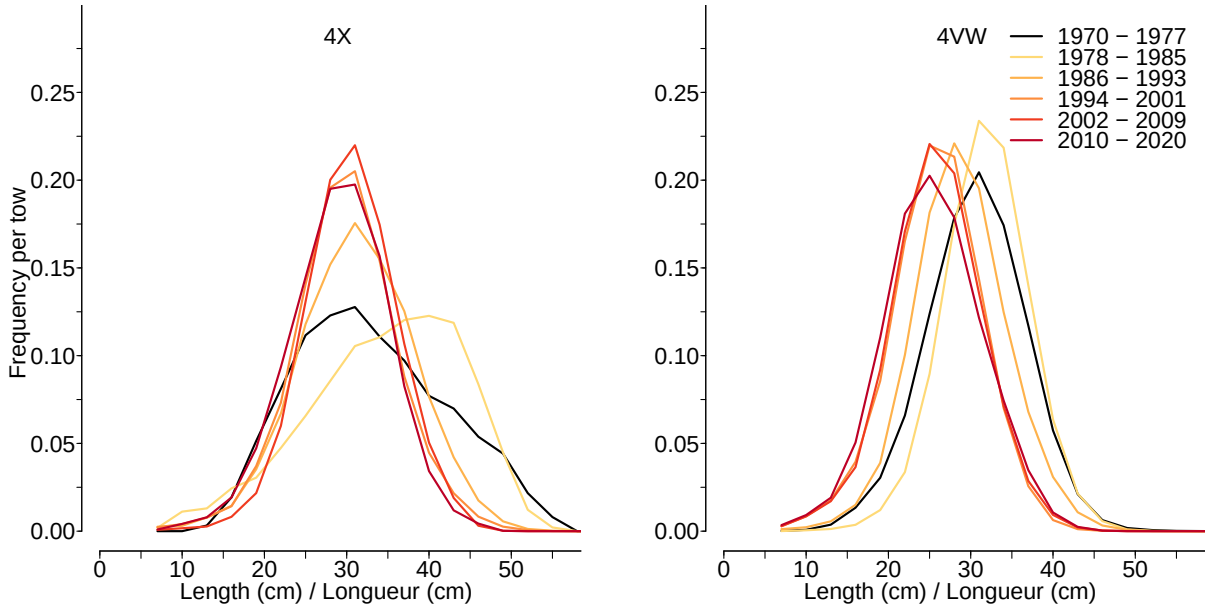


Figure 7.11C. Length frequency distribution in NAFO units 4X and 4VW for Yellowtail flounder.

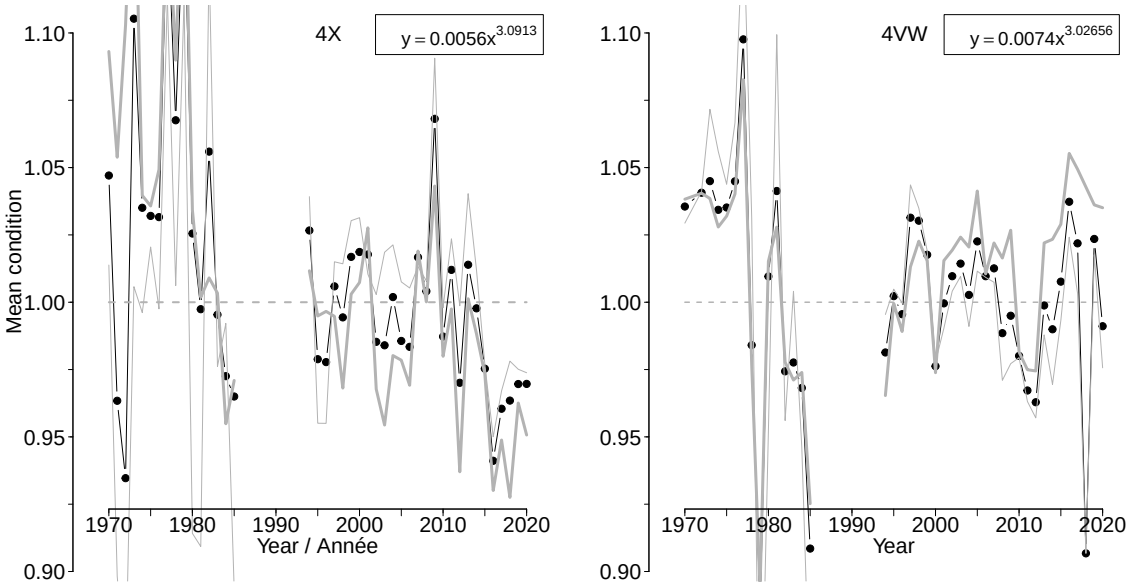
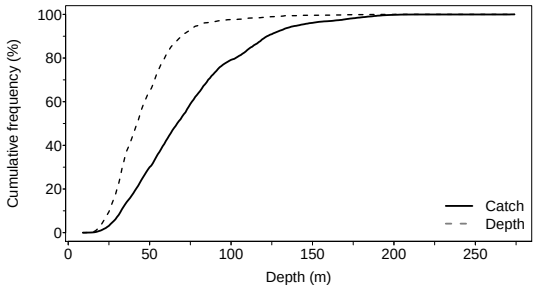
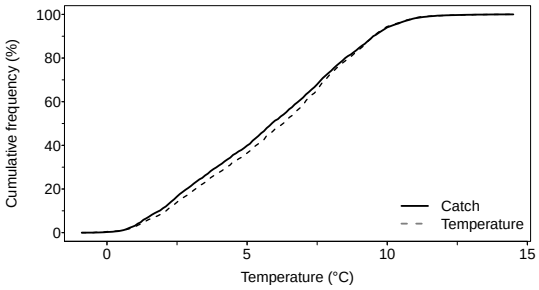
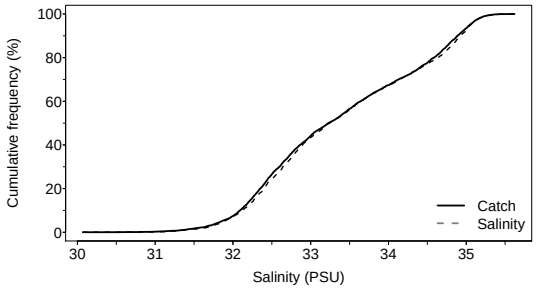


Figure 7.11D. Average fish condition in NAFO units 4X and 4VW for Yellowtail flounder.







Freq	Depth	Temp	Sal
F5	22	1.4	31.00
F25	32	3.7	32.52
F50	43	6.3	33.25
F75	56	8.2	34.41
F95	81	10.0	35.06

Figure 7.11E. Catch distribution by depth, temperature and salinity of Yellowtail flounder.

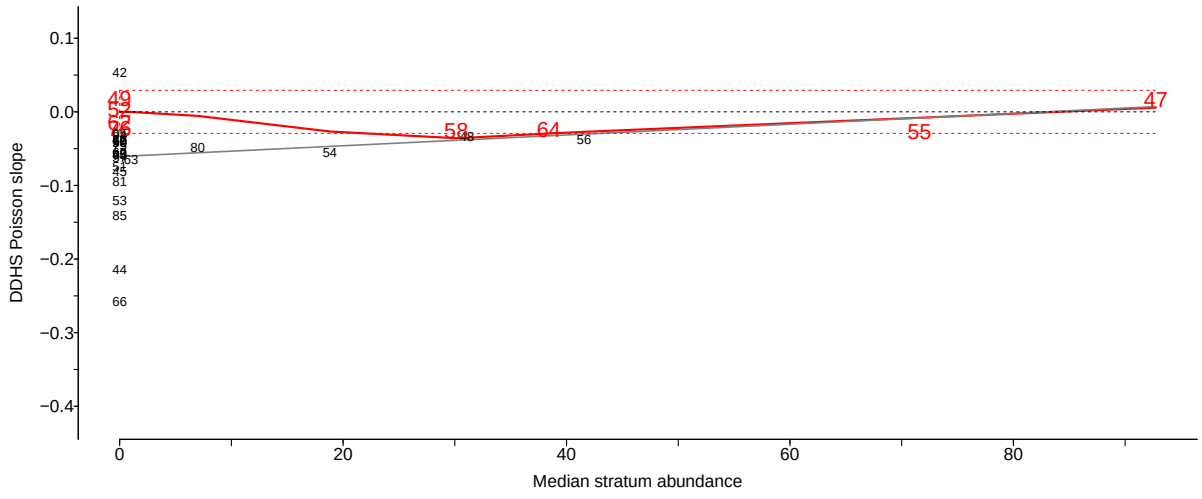


Figure 7.11F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Yellowtail flounder.

7.12 Winter flounder (Limande-plie rouge) - species code 43 (category LF)

Scientific name: Pseudopleuronectes americanus

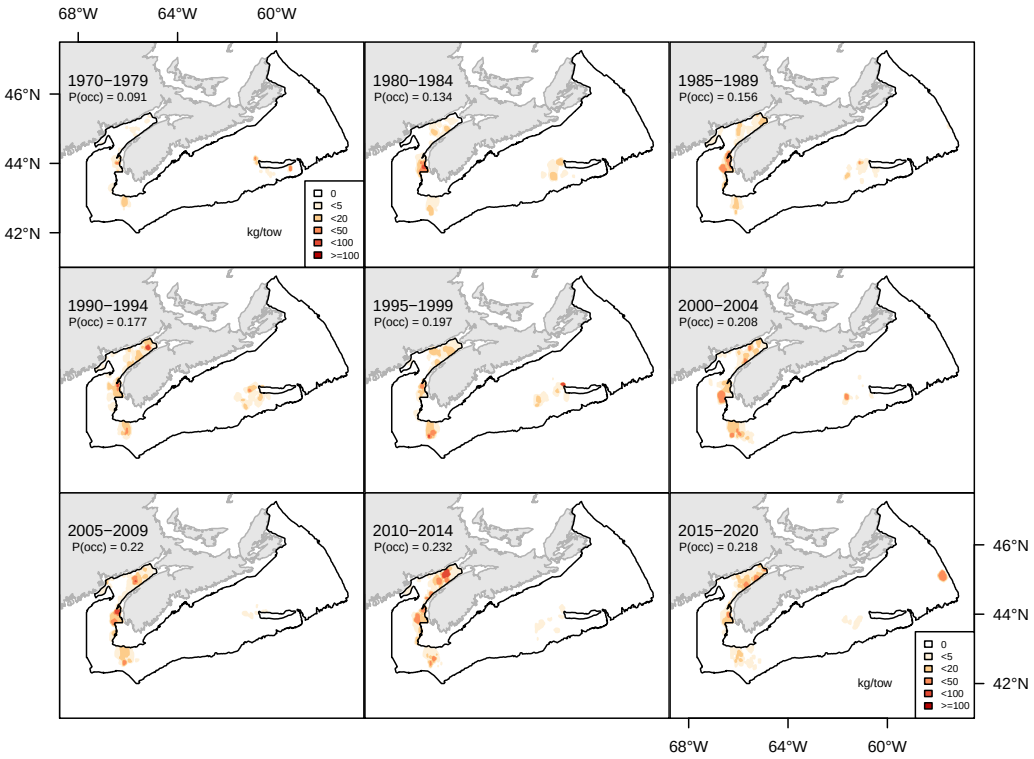


Figure 7.12A. Inverse distance weighted distribution of catch biomass (kg/tow) for Winter flounder.

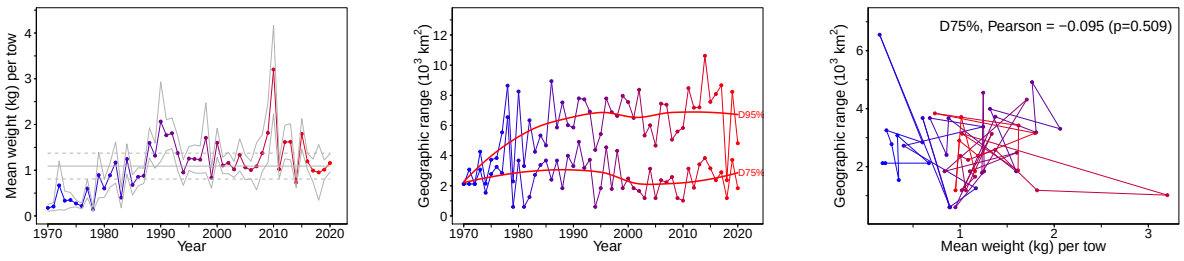


Figure 7.12B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Winter flounder.

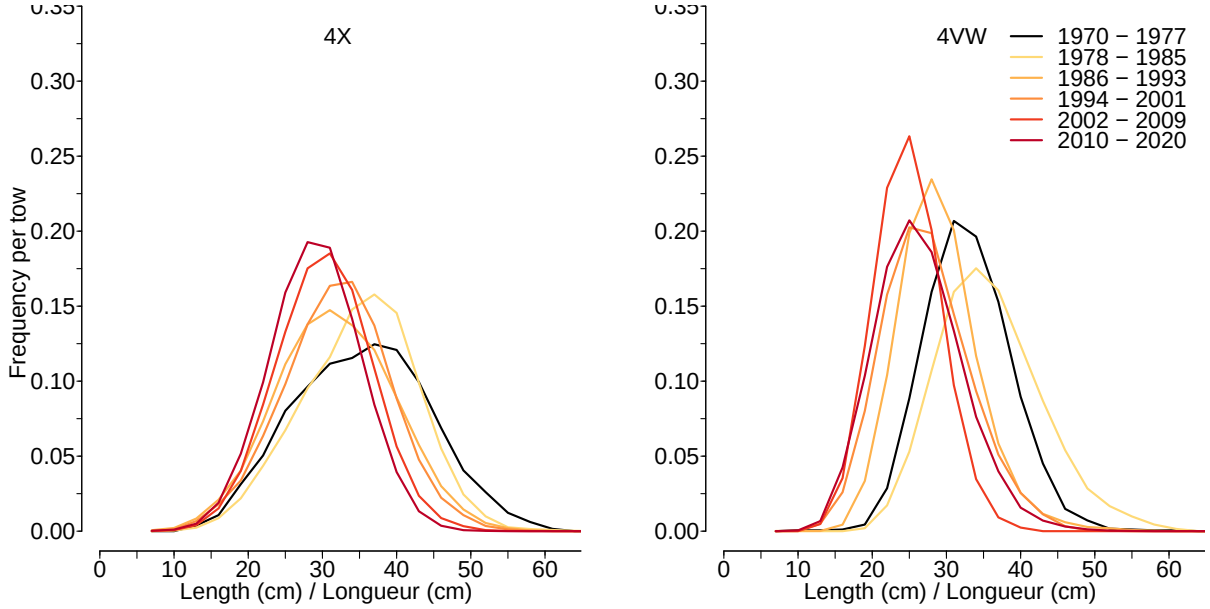


Figure 7.12C. Length frequency distribution in NAFO units 4X and 4VW for Winter flounder.

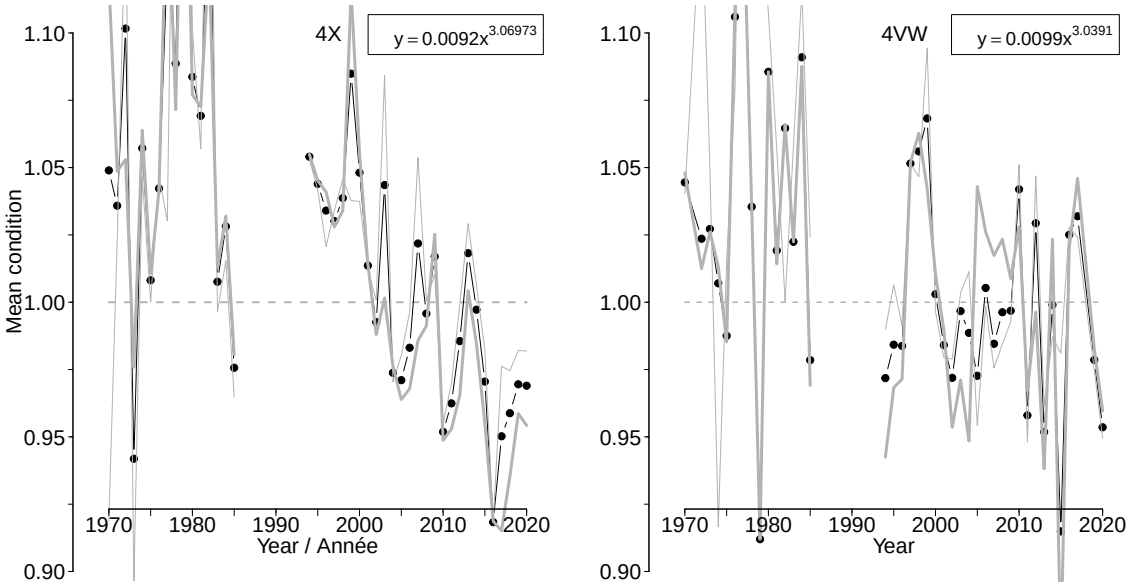
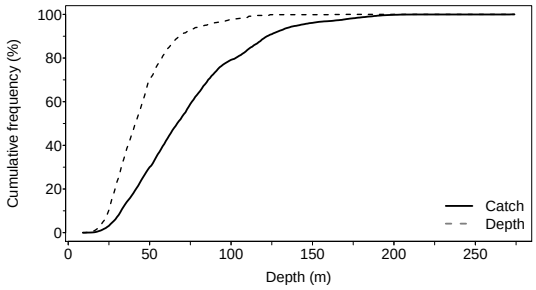
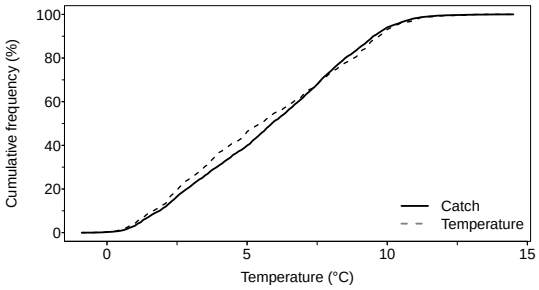
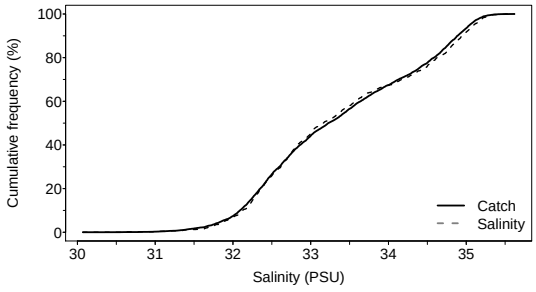


Figure 7.12D. Average fish condition in NAFO units 4X and 4VW for Winter flounder.







Freq	Depth	Temp	Sal
F5	22	1.1	31.00
F25	31	3.0	32.48
F50	42	5.5	33.17
F75	54	8.3	34.47
F95	84	10.0	35.10

Figure 7.12E. Catch distribution by depth, temperature and salinity of Winter flounder.

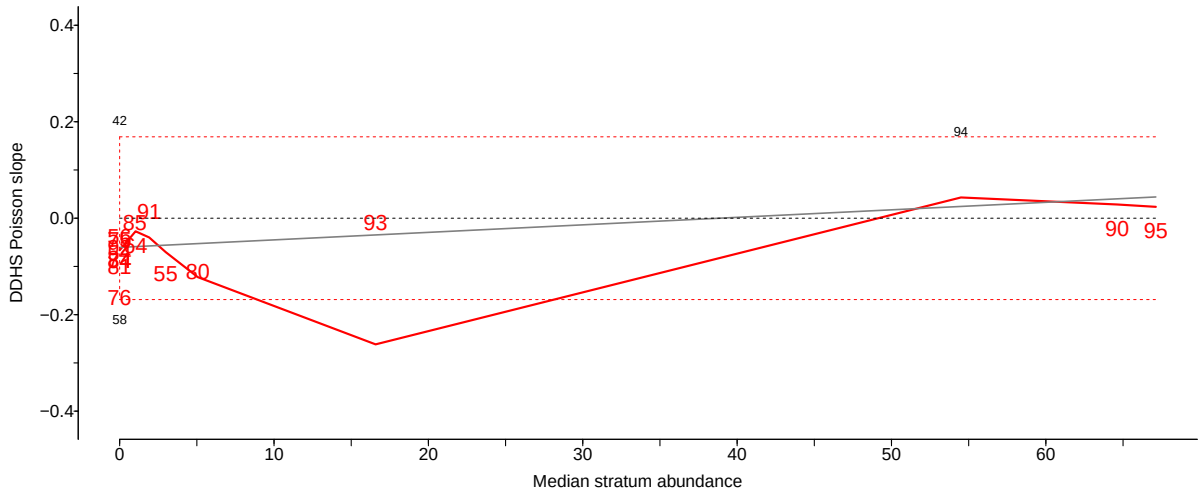


Figure 7.12F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Winter flounder.

7.13 Atlantic wolffish (Loup atlantique) - species code 50 (category LF)

Scientific name: Anarhichas lupus

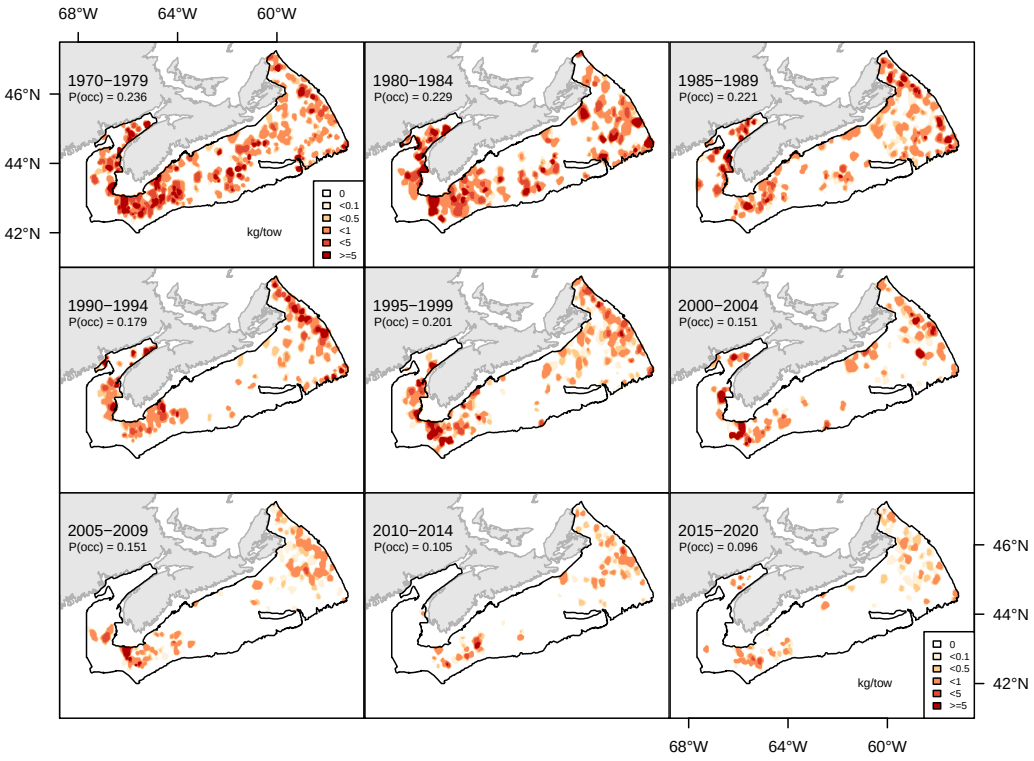


Figure 7.13A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic wolffish.

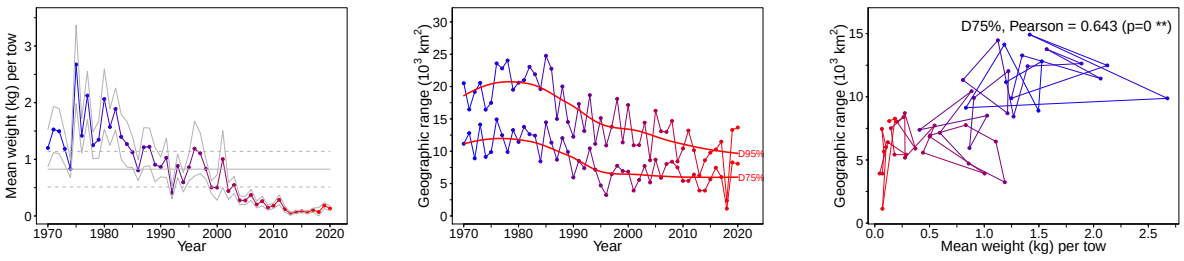


Figure 7.13B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic wolffish.

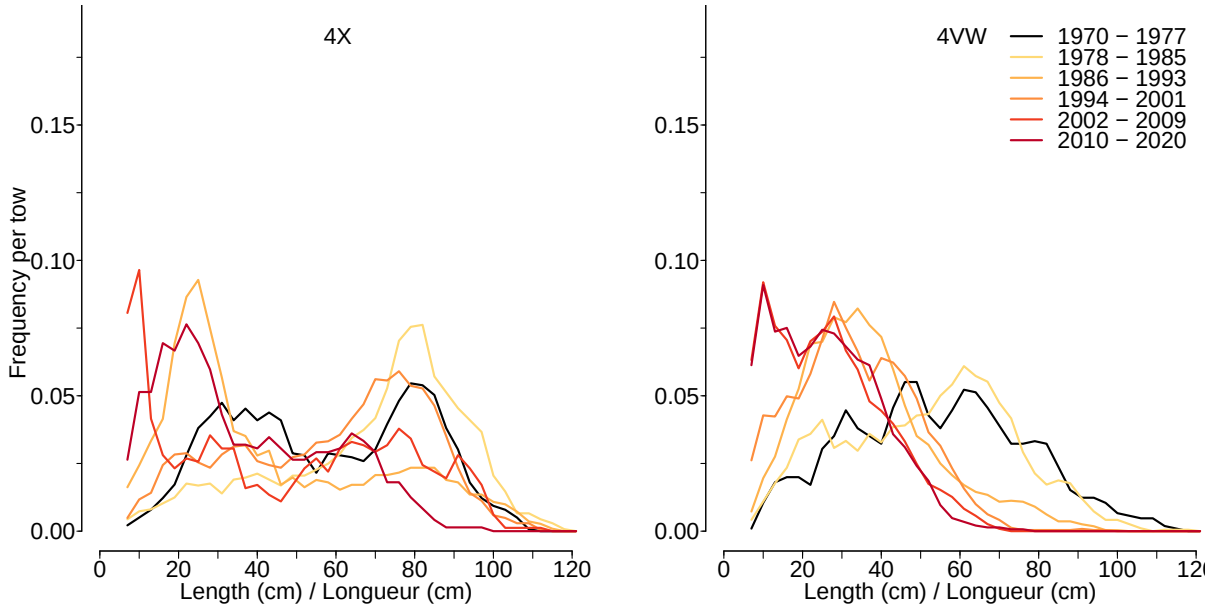


Figure 7.13C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic wolffish.

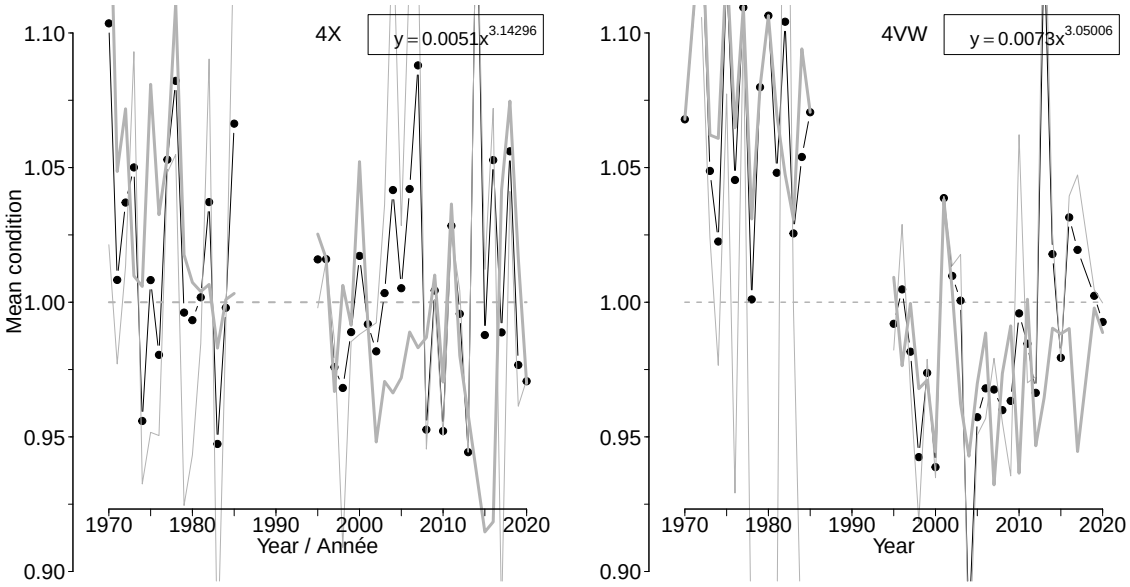
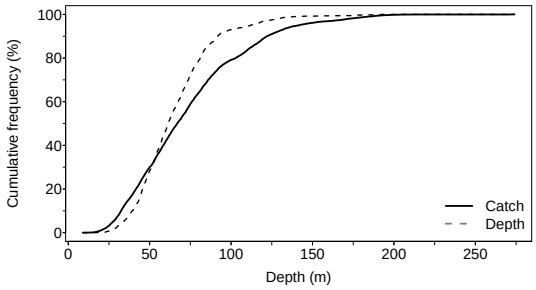
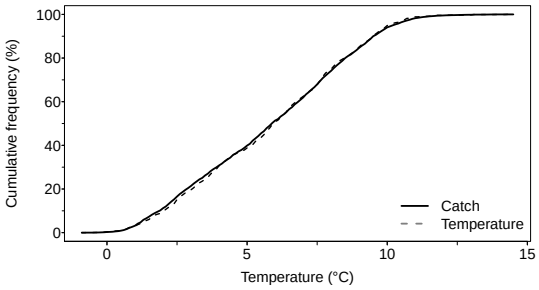
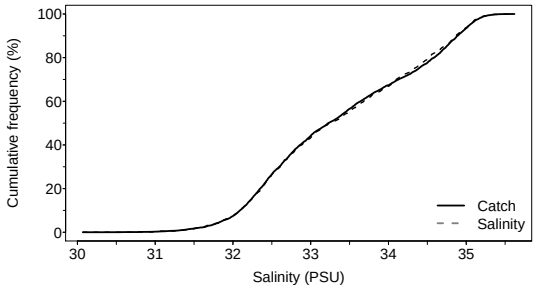


Figure 7.13D. Average fish condition in NAFO units 4X and 4VW for Atlantic wolffish.



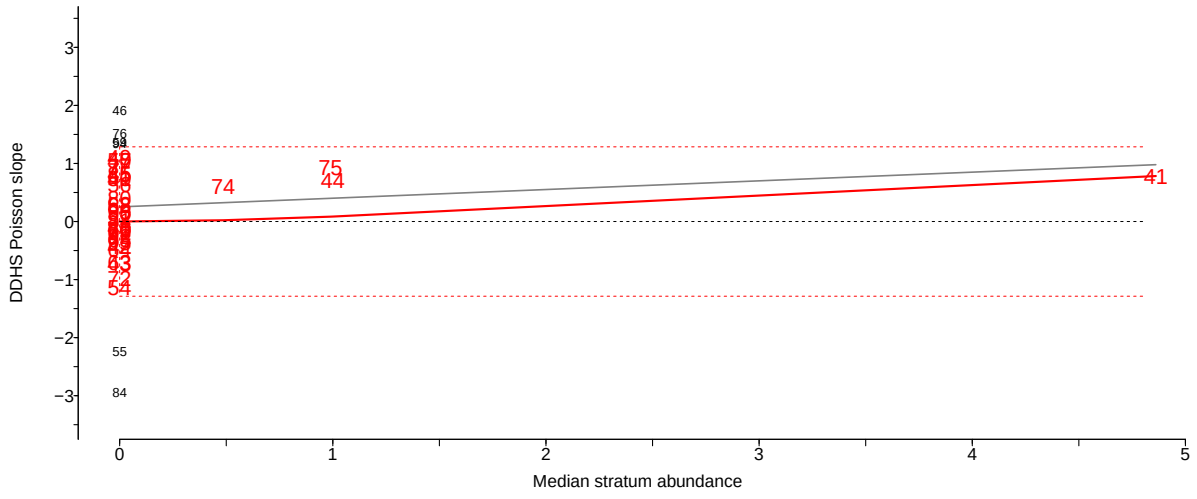


801



Freq	Depth	Temp	Sal
F5	34	1.4	31.00
F25	49	3.6	32.48
F50	62	6.0	33.25
F75	77	8.1	34.33
F95	112	10.0	35.05

Figure 7.13E. Catch distribution by depth, temperature and salinity of Atlantic wolffish.



802

Figure 7.13F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic wolffish.

7.14 Atlantic herring (Hareng de l'Atlantique) - species code 60 (category LF)

Scientific name: Clupea harengus

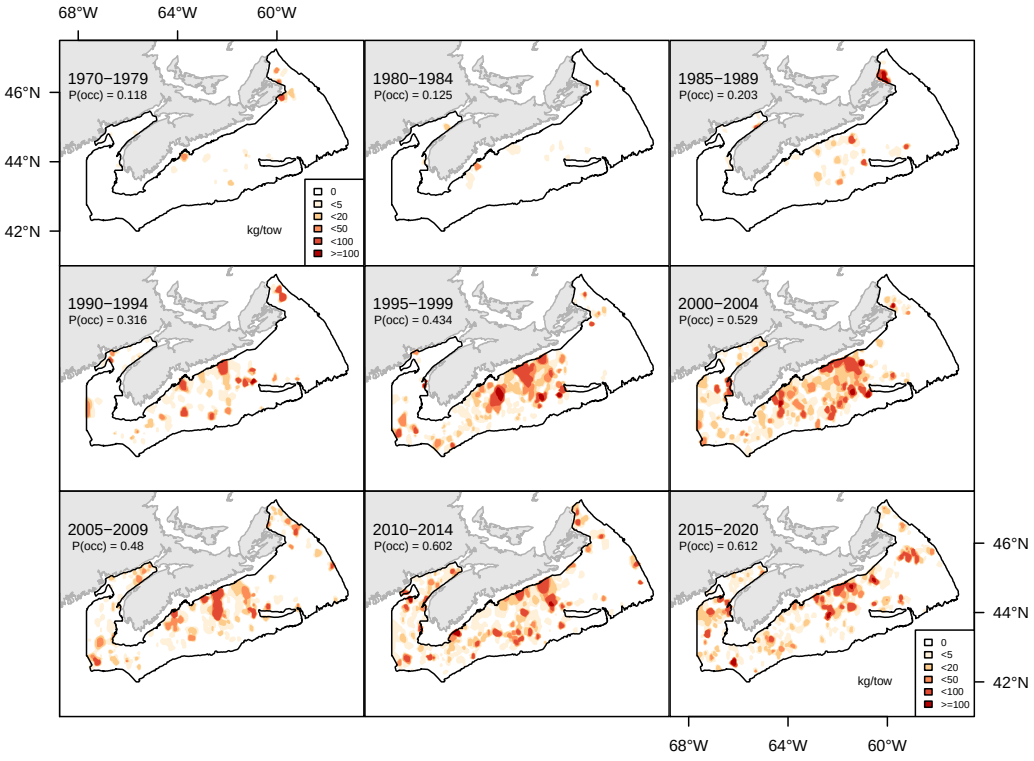


Figure 7.14A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic herring.

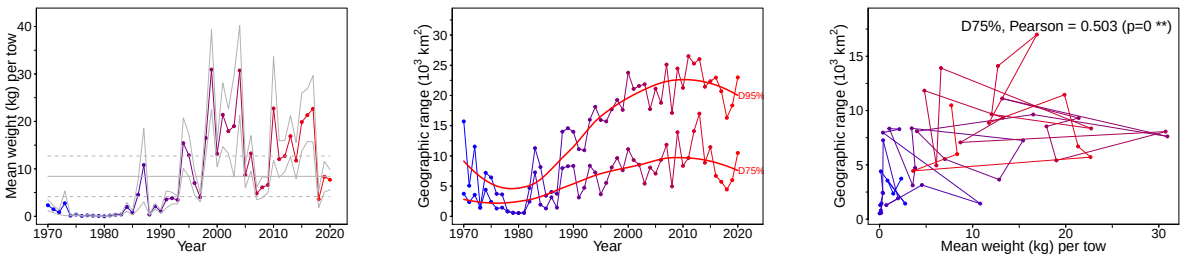


Figure 7.14B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic herring.

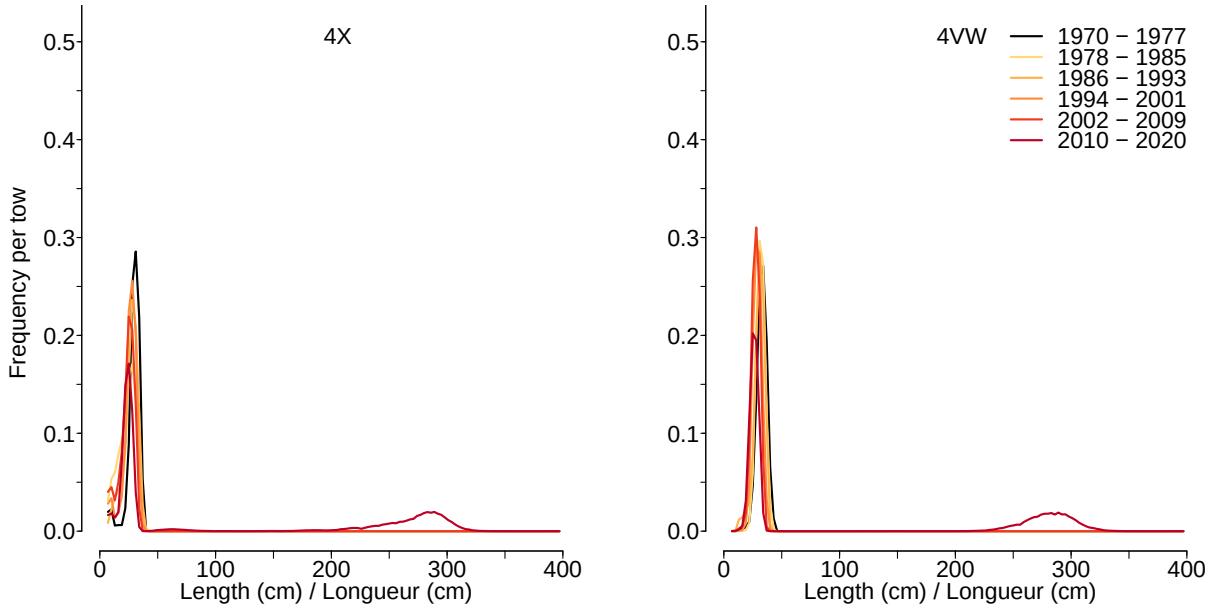


Figure 7.14C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic herring.

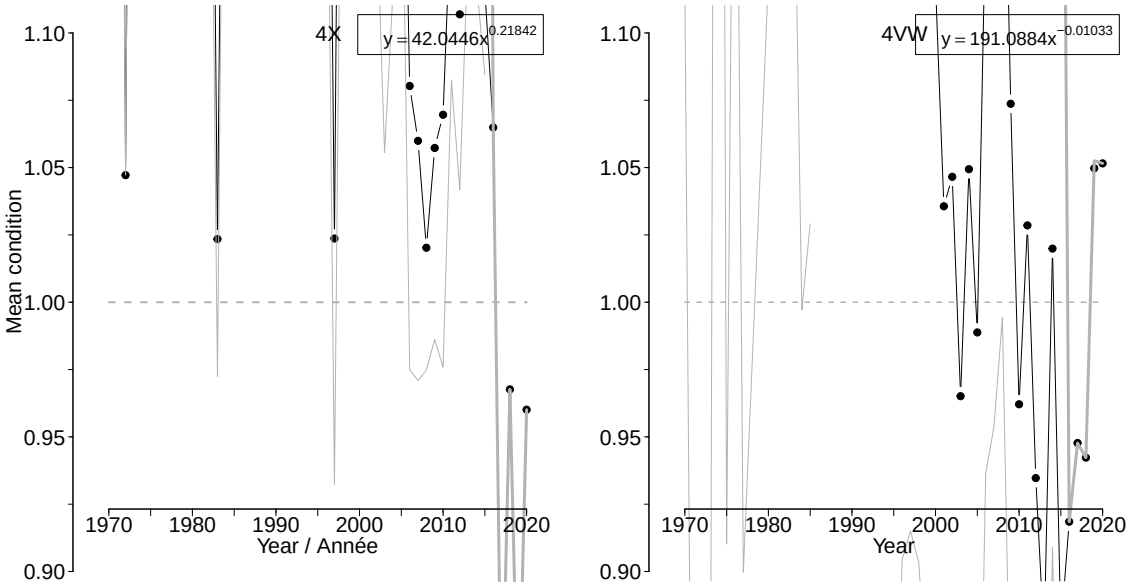
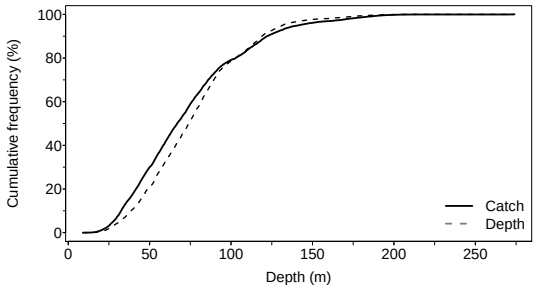
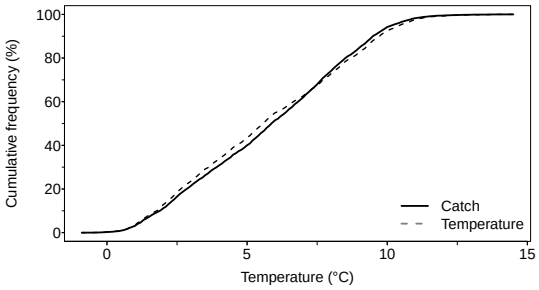
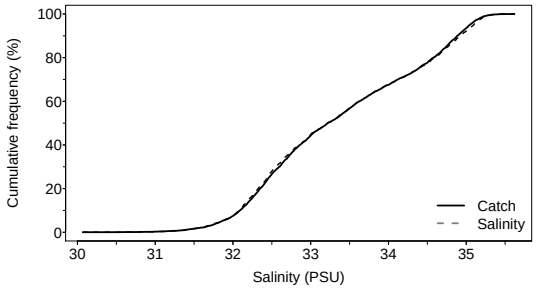


Figure 7.14D. Average fish condition in NAFO units 4X and 4VW for Atlantic herring.







Freq	Depth	Temp	Sal
F5	32	1.2	31.00
F25	54	3.2	32.45
F50	74	5.6	33.22
F75	95	8.3	34.38
F95	132	10.0	35.10

Figure 7.14E. Catch distribution by depth, temperature and salinity of Atlantic herring.

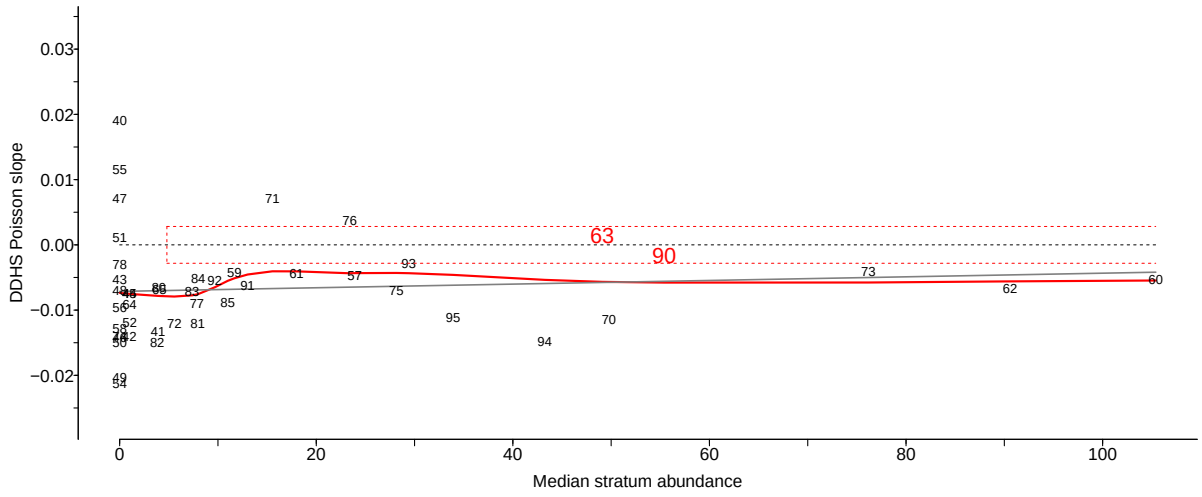


Figure 7.14F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Atlantic herring.

7.15 Longhorn sculpin (Chaboisseau à dix-huit épines) - species code 300 (category LF)

Scientific name: Myoxocephalus octodecemspinosus

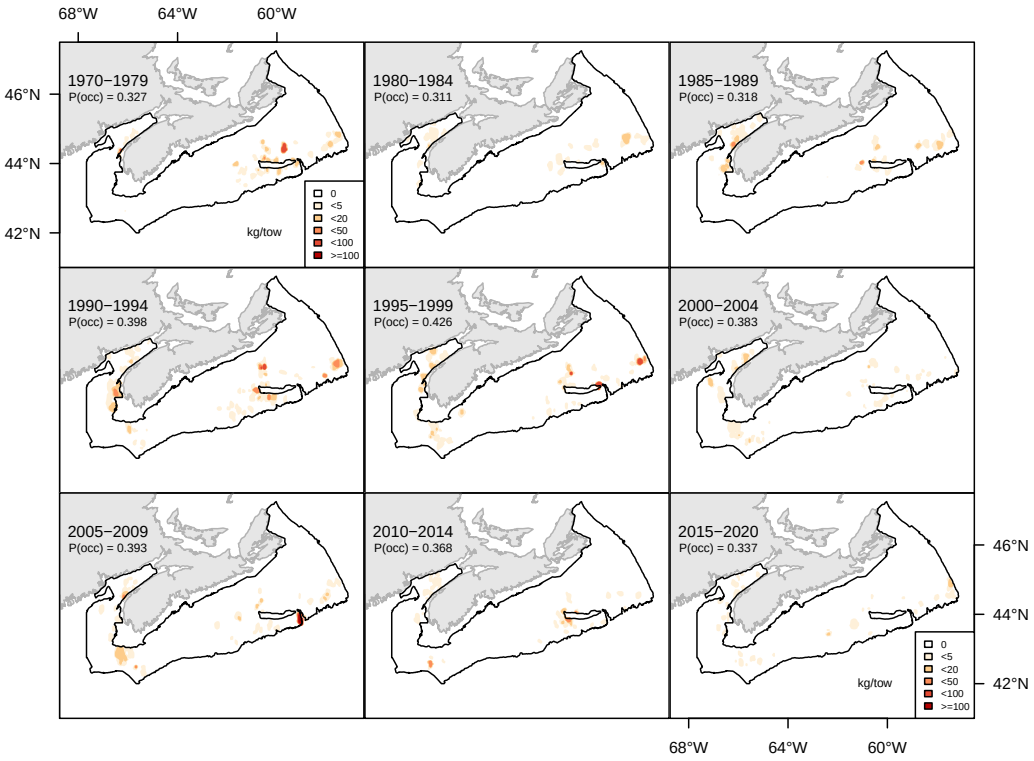


Figure 7.15A. Inverse distance weighted distribution of catch biomass (kg/tow) for Longhorn sculpin.

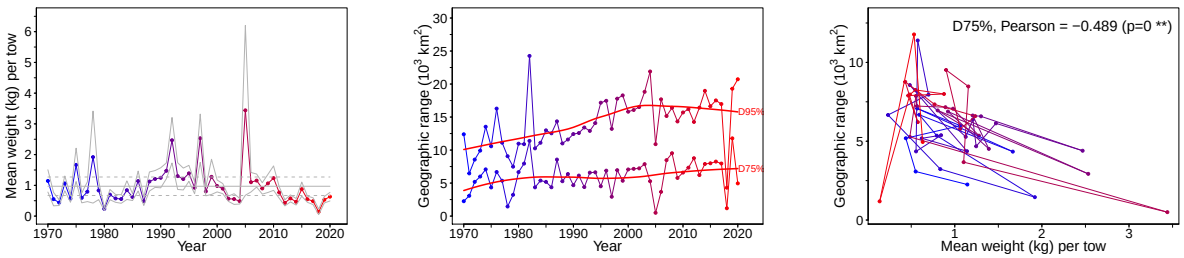


Figure 7.15B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Longhorn sculpin.

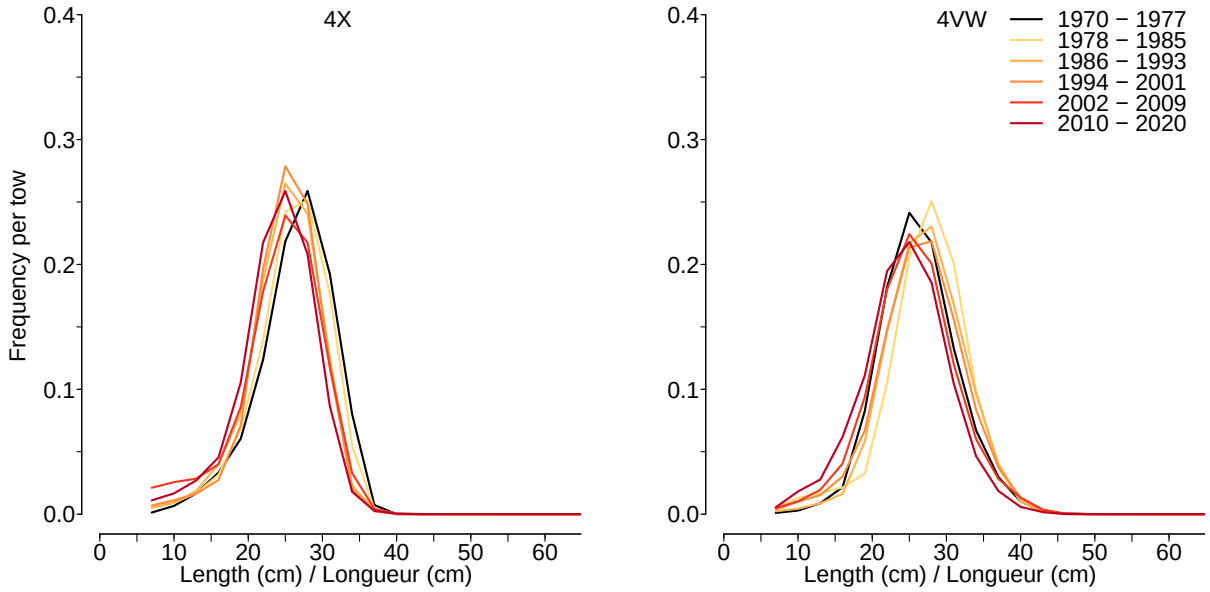


Figure 7.15C. Length frequency distribution in NAFO units 4X and 4VW for Longhorn sculpin.

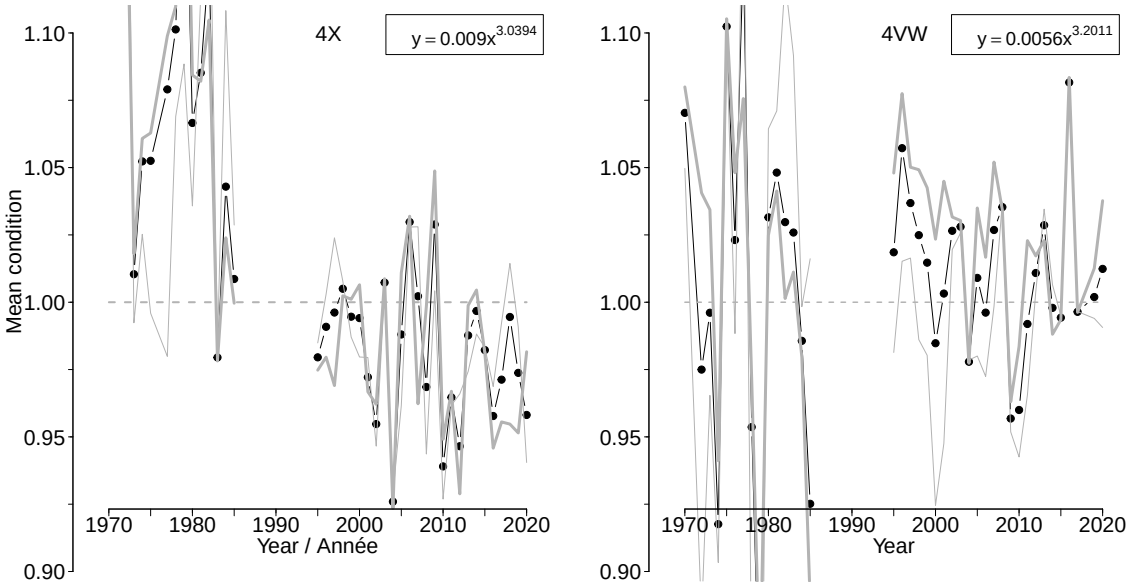
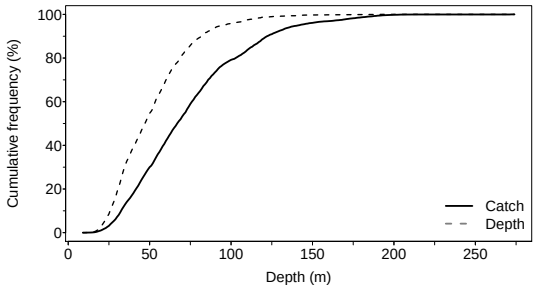
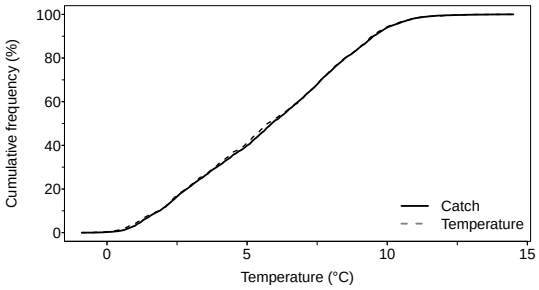
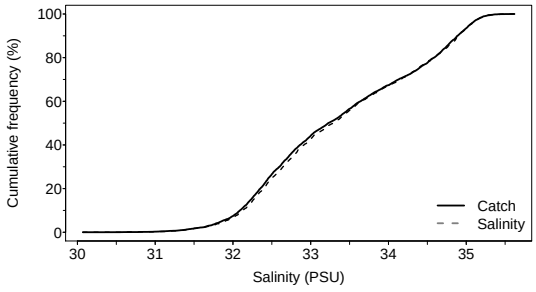


Figure 7.15D. Average fish condition in NAFO units 4X and 4VW for Longhorn sculpin.







Freq	Depth	Temp	Sal
F5	23	1.2	31.00
F25	33	3.3	32.51
F50	48	5.8	33.29
F75	64	8.1	34.38
F95	96	10.0	35.05

Figure 7.15E. Catch distribution by depth, temperature and salinity of Longhorn sculpin.

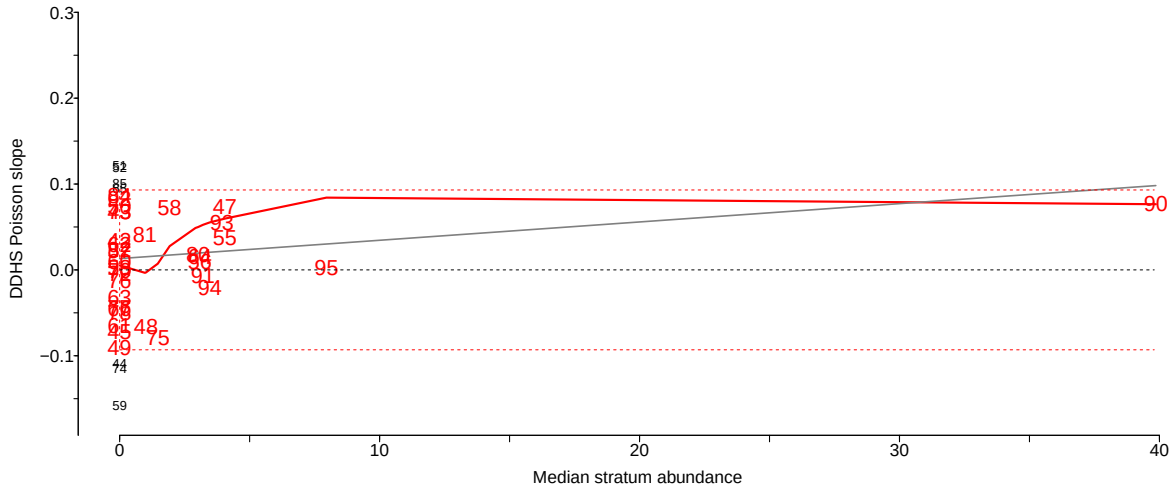


Figure 7.15F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Longhorn sculpin.

7.16 Moustache sculpin (Faux-trigle armé) - species code 304 (category LF)

Scientific name: Triglops murrayi

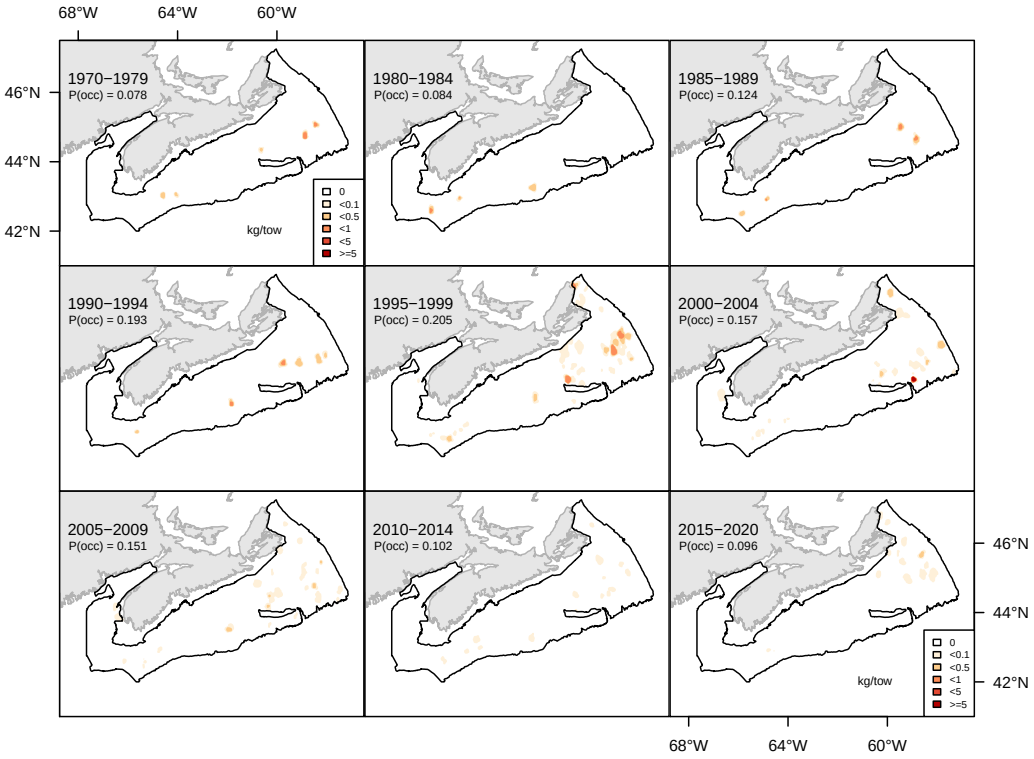


Figure 7.16A. Inverse distance weighted distribution of catch biomass (kg/tow) for Moustache sculpin.

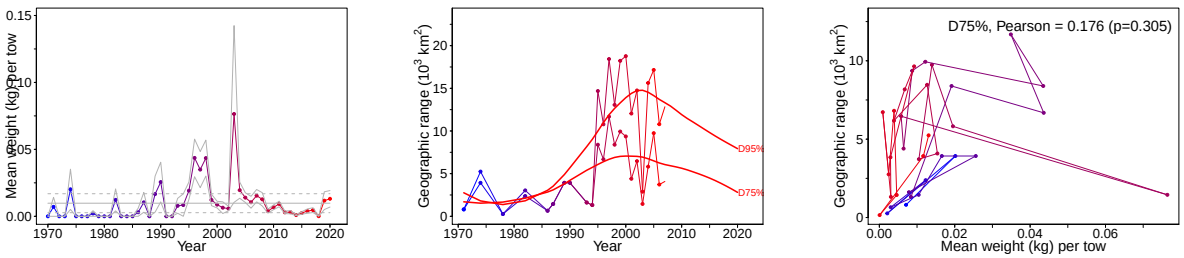


Figure 7.16B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Moustache sculpin.

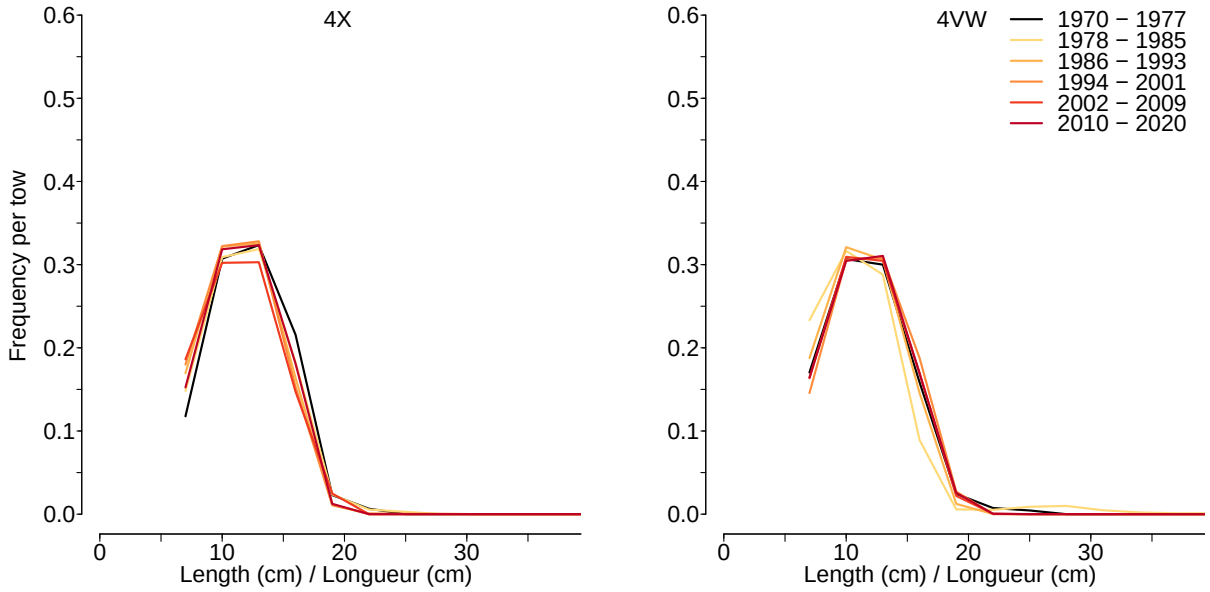


Figure 7.16C. Length frequency distribution in NAFO units 4X and 4VW for Moustache sculpin.

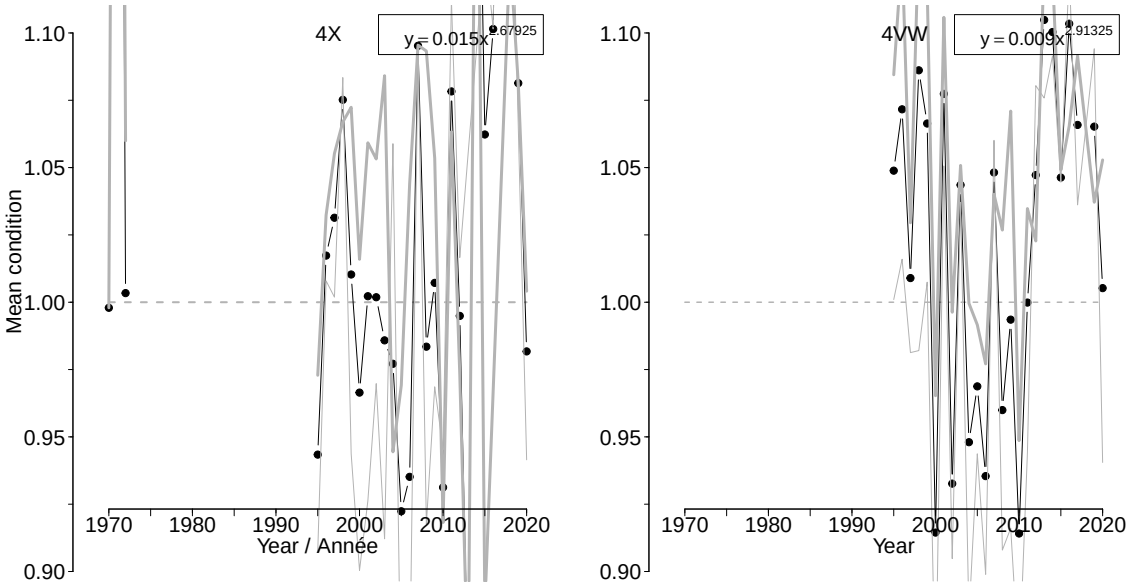
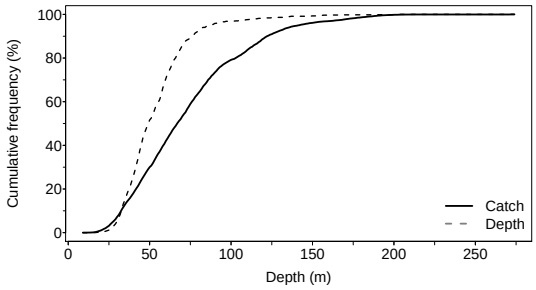
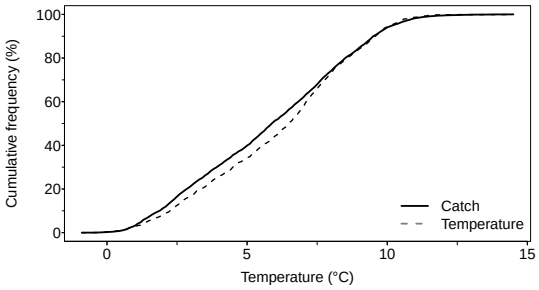
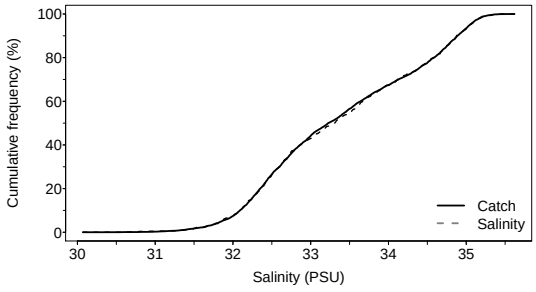


Figure 7.16D. Average fish condition in NAFO units 4X and 4VW for Moustache sculpin.



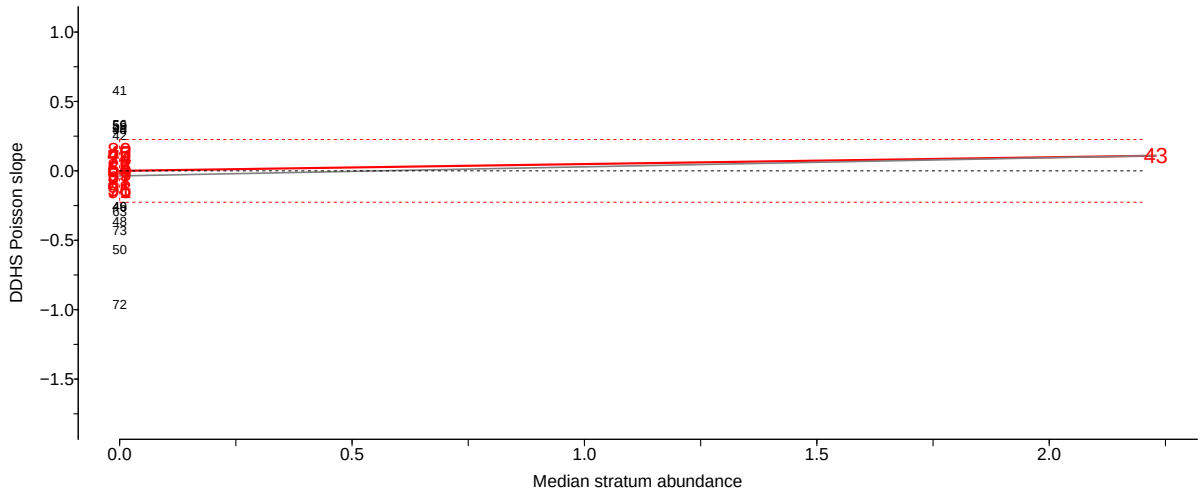


826



Freq	Depth	Temp	Sal
F5	30	1.5	31.00
F25	40	4.0	32.48
F50	50	6.5	33.31
F75	63	8.2	34.39
F95	88	10.0	35.06

Figure 7.16E. Catch distribution by depth, temperature and salinity of Moustache sculpin.



827

Figure 7.16F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Moustache sculpin.

7.17 Sea raven (Hémitriptère atlantique) - species code 320 (category LF)

Scientific name: Hemitripterus americanus

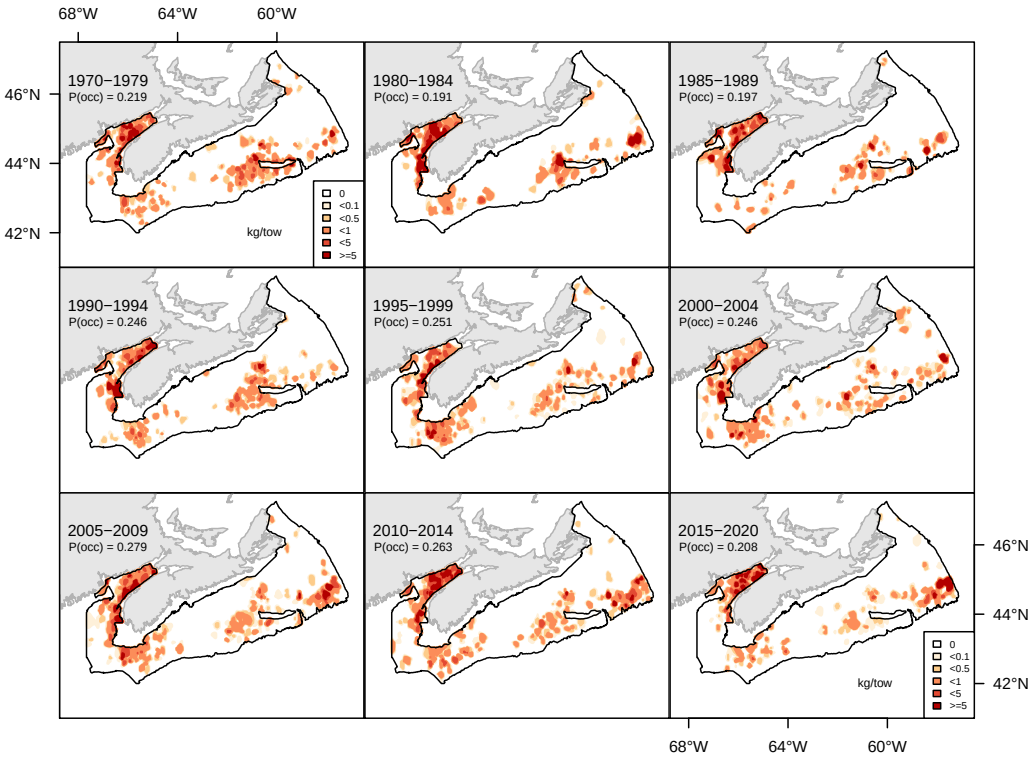


Figure 7.17A. Inverse distance weighted distribution of catch biomass (kg/tow) for Sea raven.

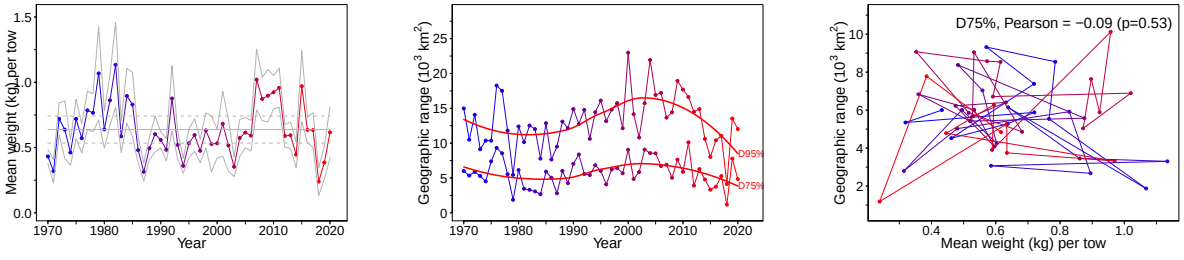


Figure 7.17B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Sea raven.

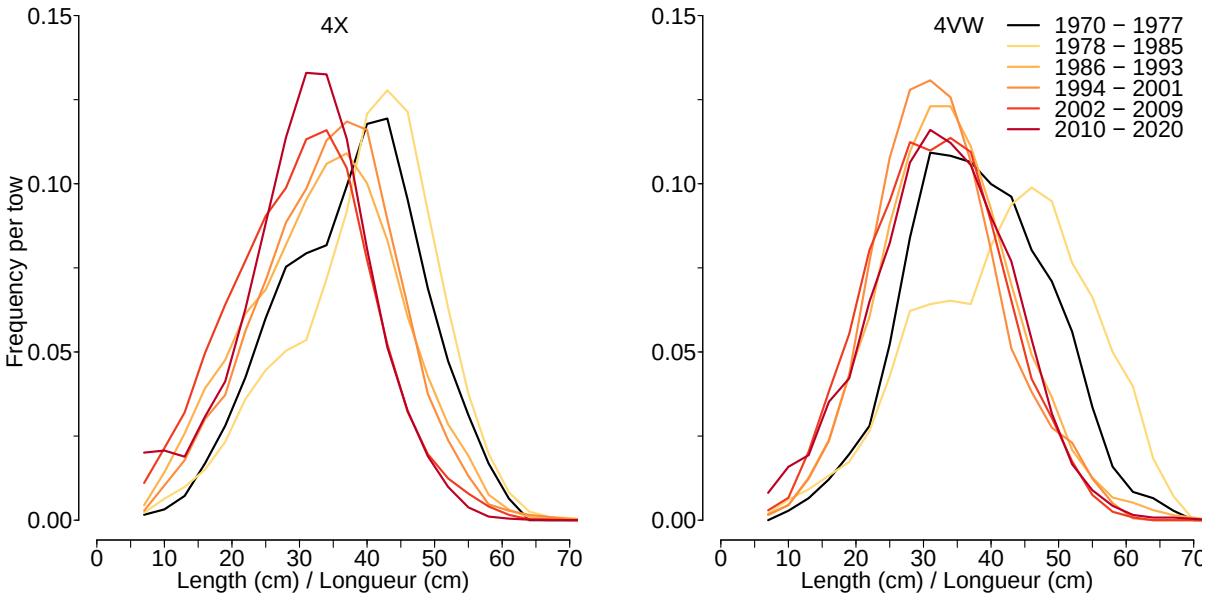


Figure 7.17C. Length frequency distribution in NAFO units 4X and 4VW for Sea raven.

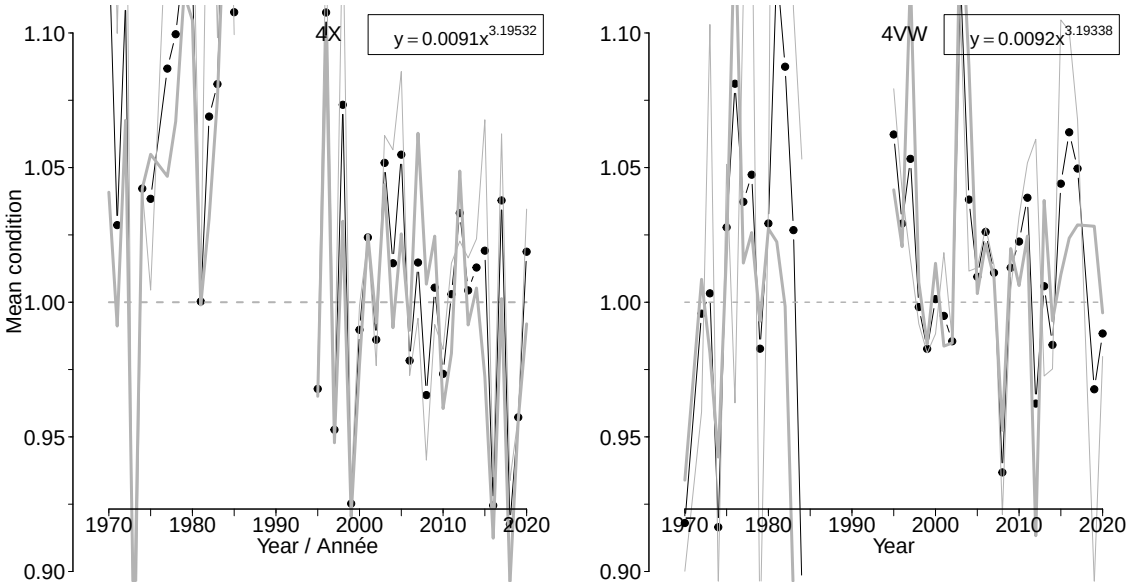
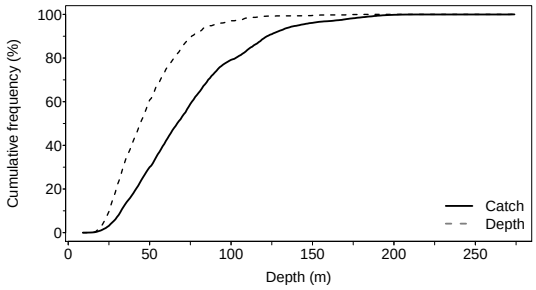
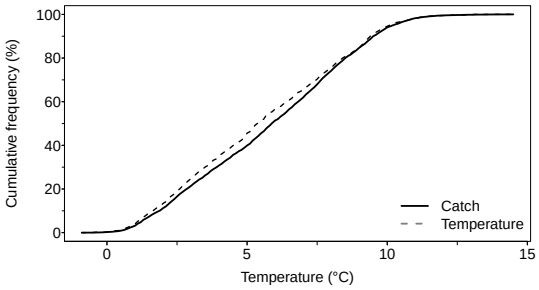
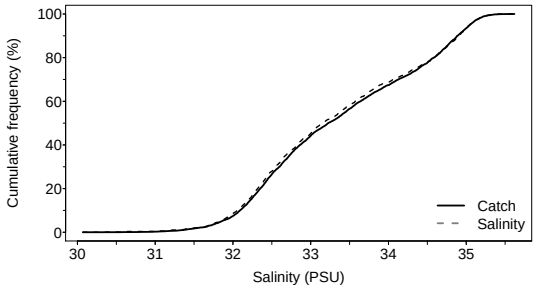


Figure 7.17D. Average fish condition in NAFO units 4X and 4VW for Sea raven.



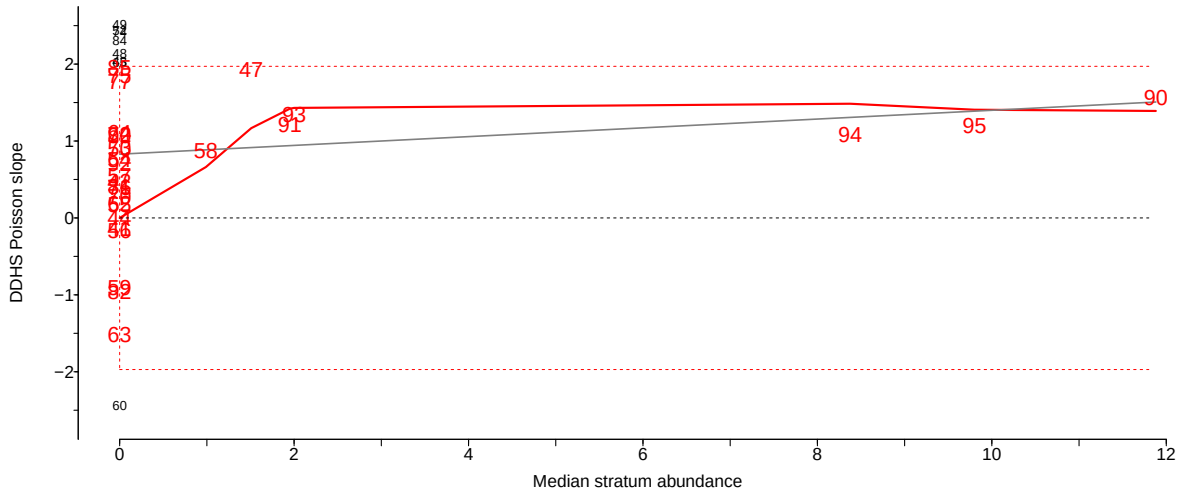


834



Freq	Depth	Temp	Sal
F5	22	1.1	31.00
F25	32	3.1	32.43
F50	45	5.4	33.15
F75	61	8.0	34.35
F95	89	10.0	35.05

Figure 7.17E. Catch distribution by depth, temperature and salinity of Sea raven.



835

Figure 7.17F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Sea raven.

7.18 Alligatorfish (Poisson-alligator atlantique) - species code 340 (category LF)

Scientific name: Aspidophoroides monopterygius

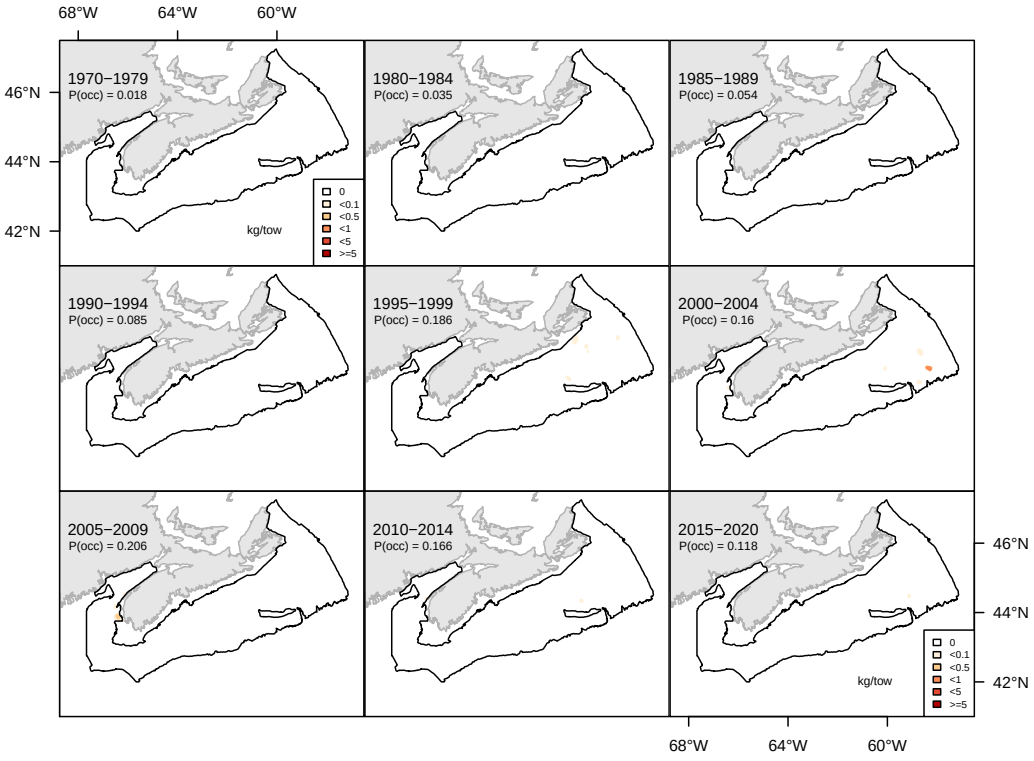


Figure 7.18A. Inverse distance weighted distribution of catch biomass (kg/tow) for Alligatorfish.

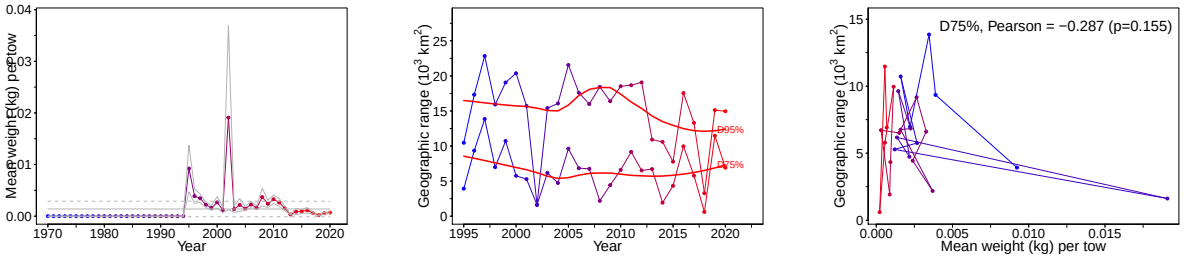


Figure 7.18B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Alligatorfish.

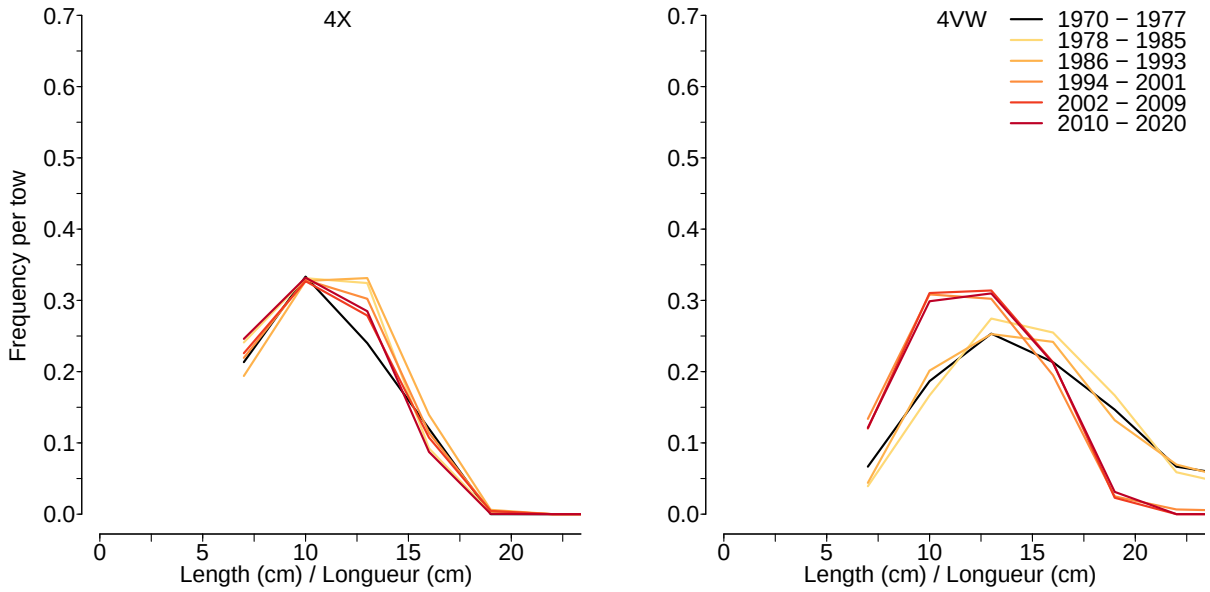


Figure 7.18C. Length frequency distribution in NAFO units 4X and 4VW for Alligatorfish.

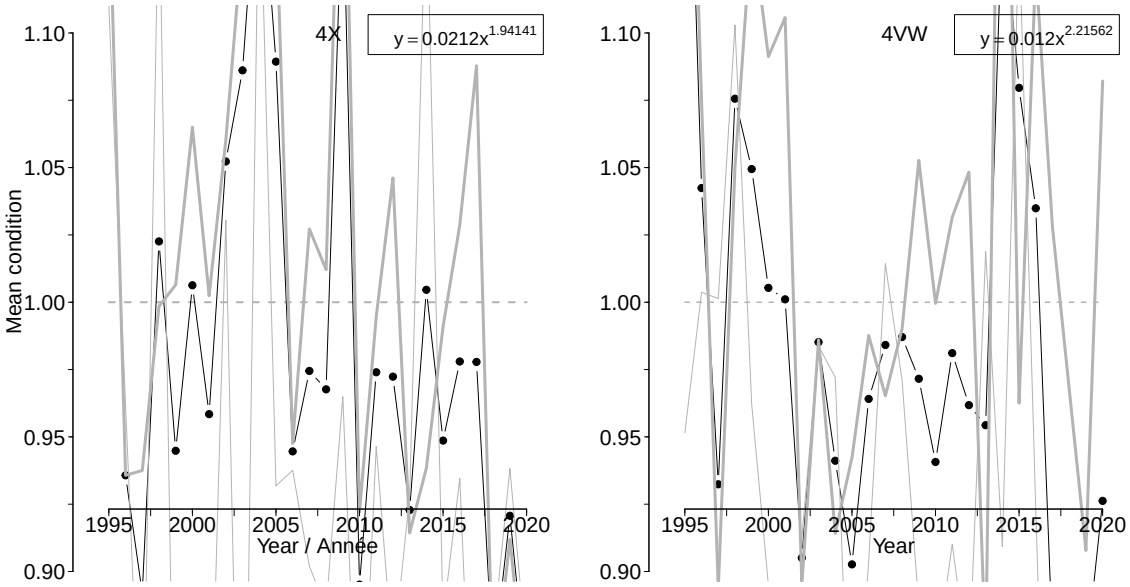
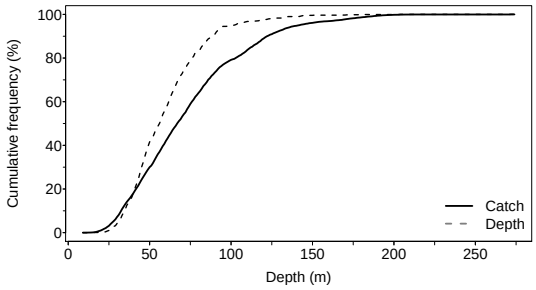
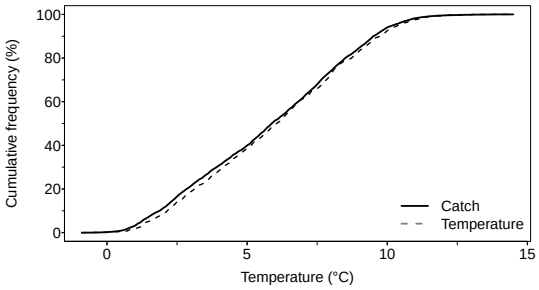
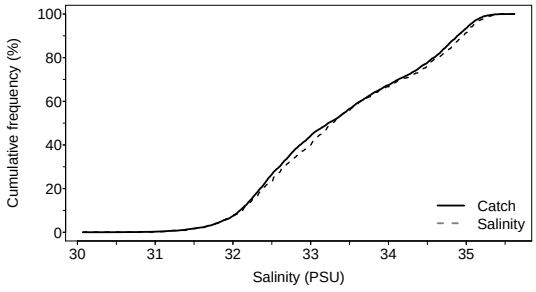


Figure 7.18D. Average fish condition in NAFO units 4X and 4VW for Alligatorfish.



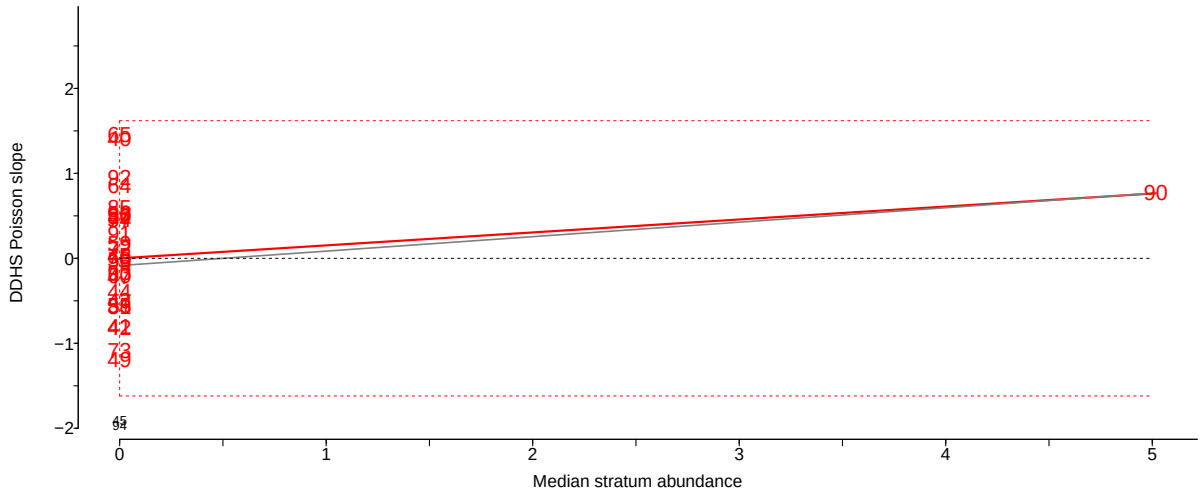


842



Freq	Depth	Temp	Sal
F5	32	1.5	31.00
F25	44	3.7	32.53
F50	57	6.1	33.28
F75	72	8.2	34.45
F95	102	10.0	35.10

Figure 7.18E. Catch distribution by depth, temperature and salinity of Alligatorfish.



843

Figure 7.18F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Alligatorfish.

7.19 Monkfish (Baudroie d'Amérique) - species code 400 (category LF)

Scientific name: Lophius americanus

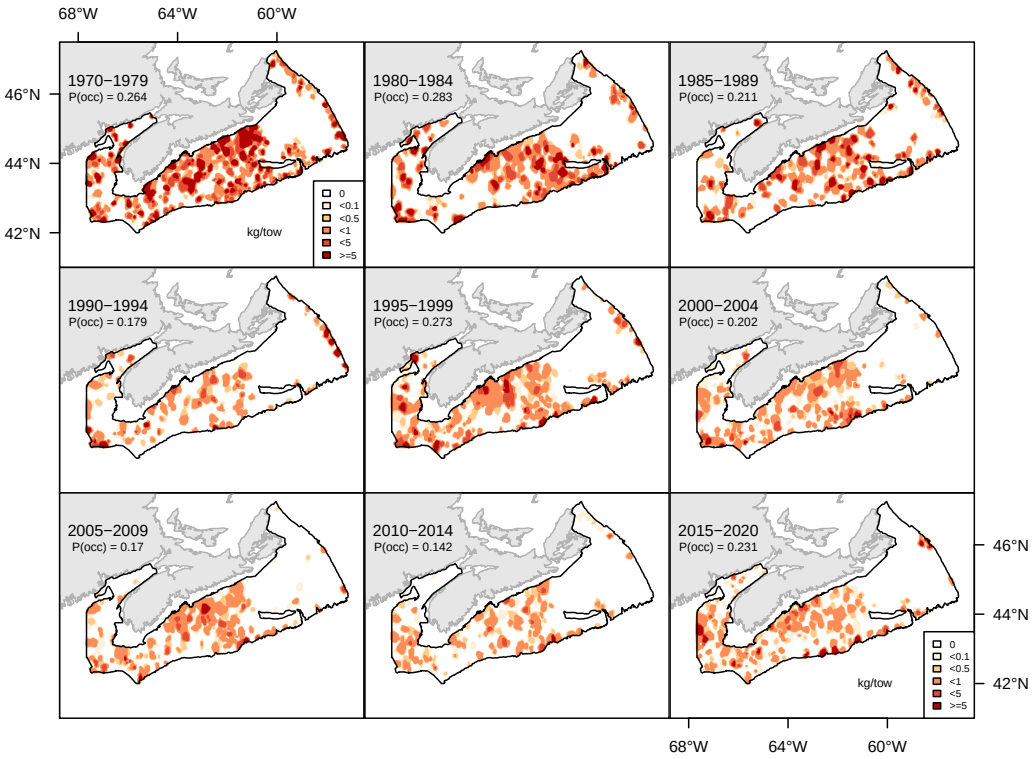


Figure 7.19A. Inverse distance weighted distribution of catch biomass (kg/tow) for Monkfish.

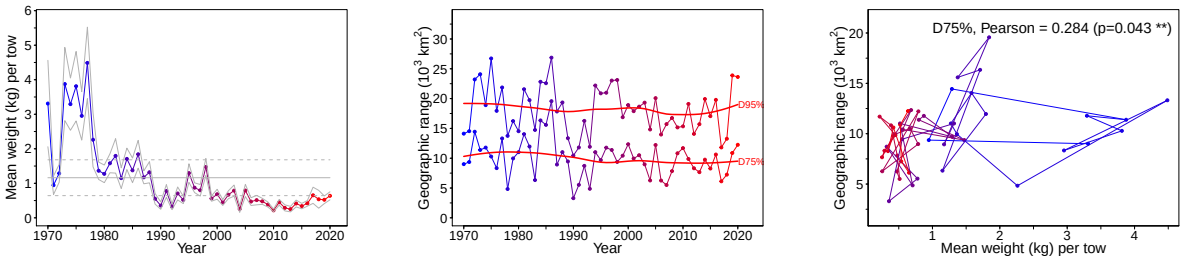


Figure 7.19B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Monkfish.

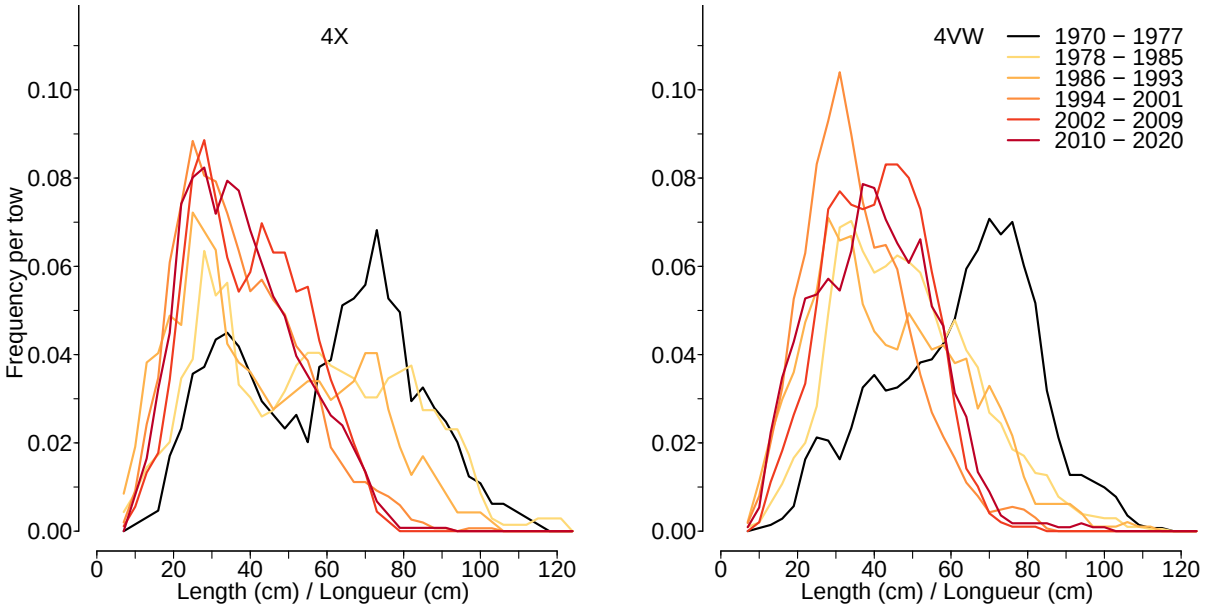


Figure 7.19C. Length frequency distribution in NAFO units 4X and 4VW for Monkfish.

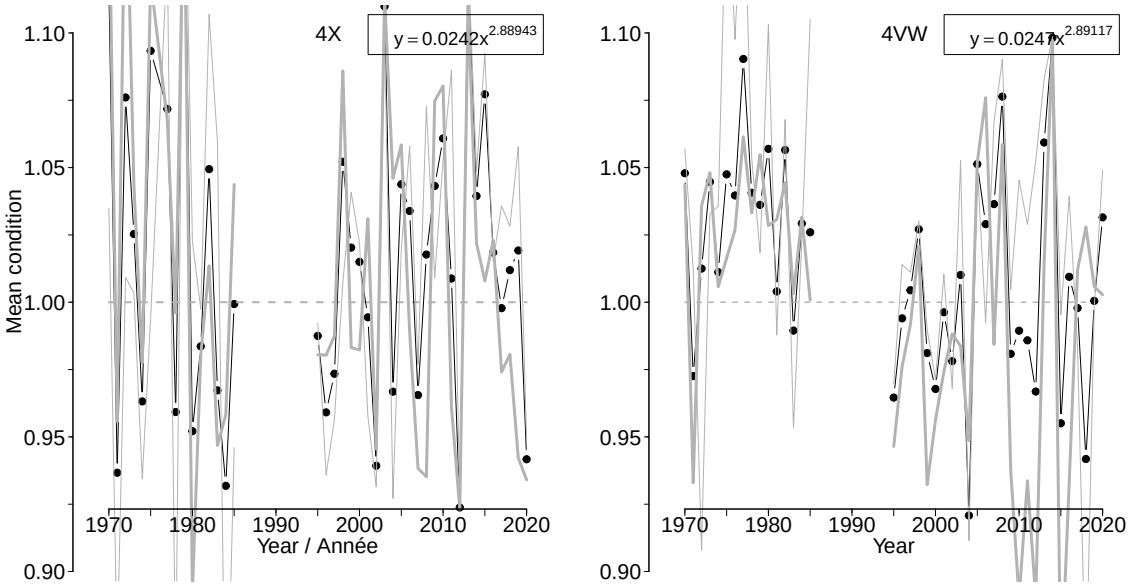
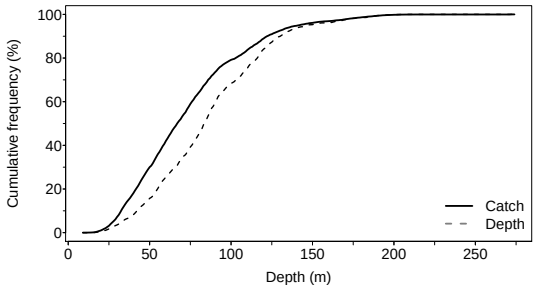
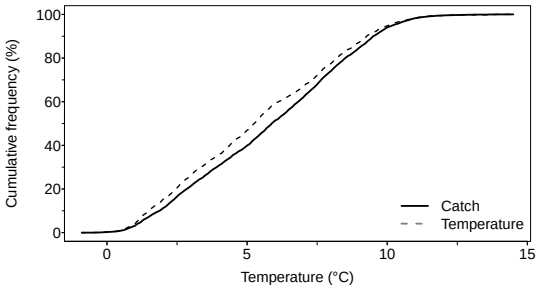
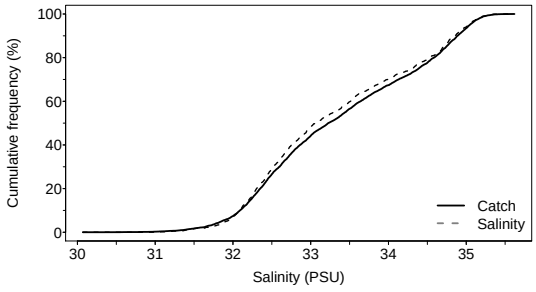


Figure 7.19D. Average fish condition in NAFO units 4X and 4VW for Monkfish.







Freq	Depth	Temp	Sal
F5	33	1.1	31.00
F25	60	2.9	32.43
F50	84	5.3	33.07
F75	110	7.8	34.31
F95	148	10.0	35.03

Figure 7.19E. Catch distribution by depth, temperature and salinity of Monkfish.

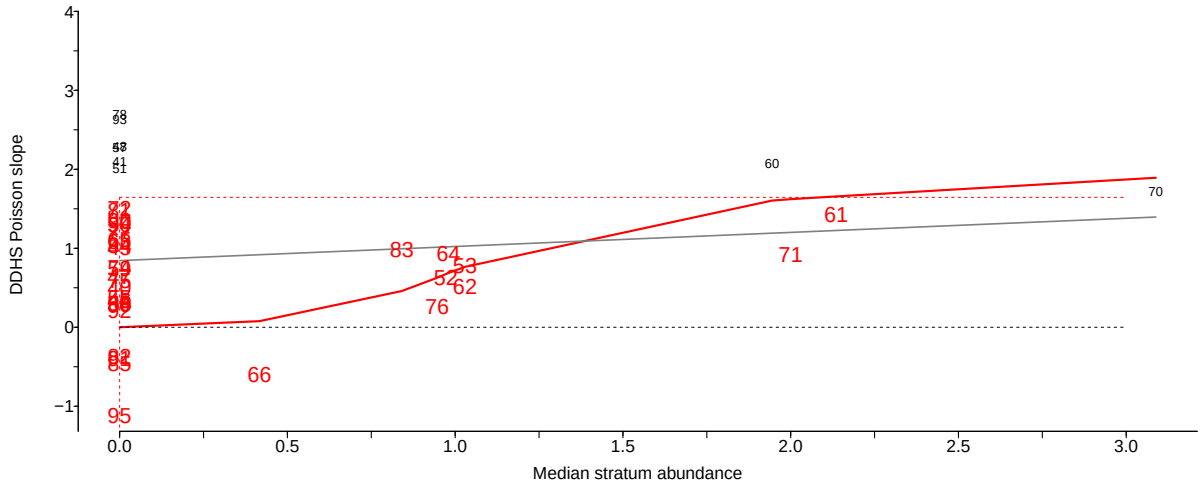


Figure 7.19F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Monkfish.

7.20 Ocean pout (Loquette d'Amérique) - species code 640 (category LF)

Scientific name: Zoarces americanus

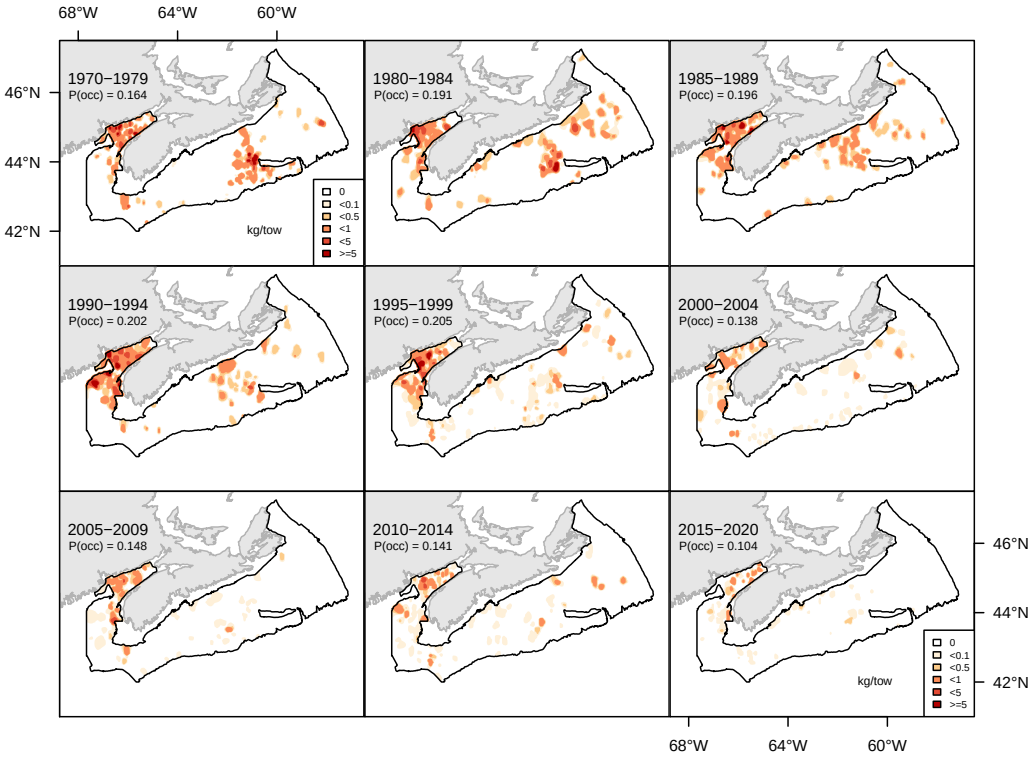


Figure 7.20A. Inverse distance weighted distribution of catch biomass (kg/tow) for Ocean pout.

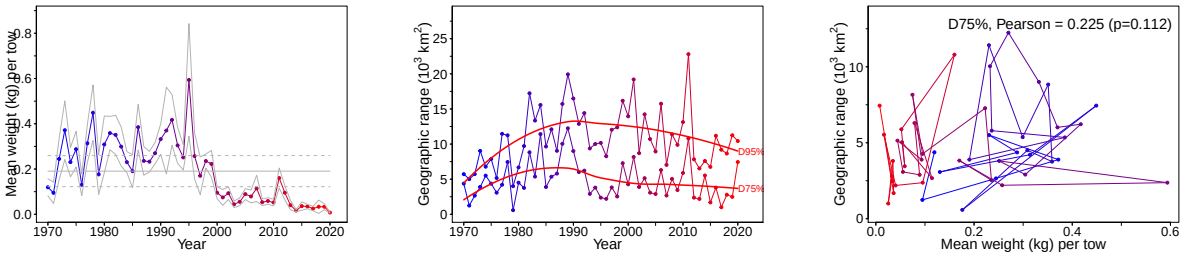


Figure 7.20B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Ocean pout.

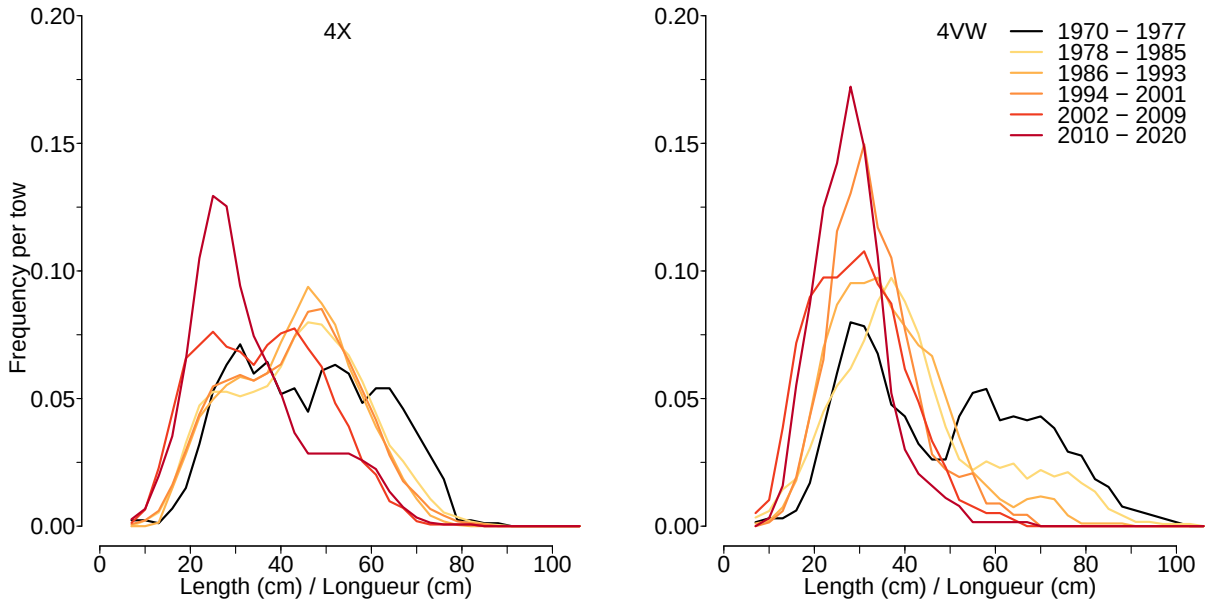


Figure 7.20C. Length frequency distribution in NAFO units 4X and 4VW for Ocean pout.

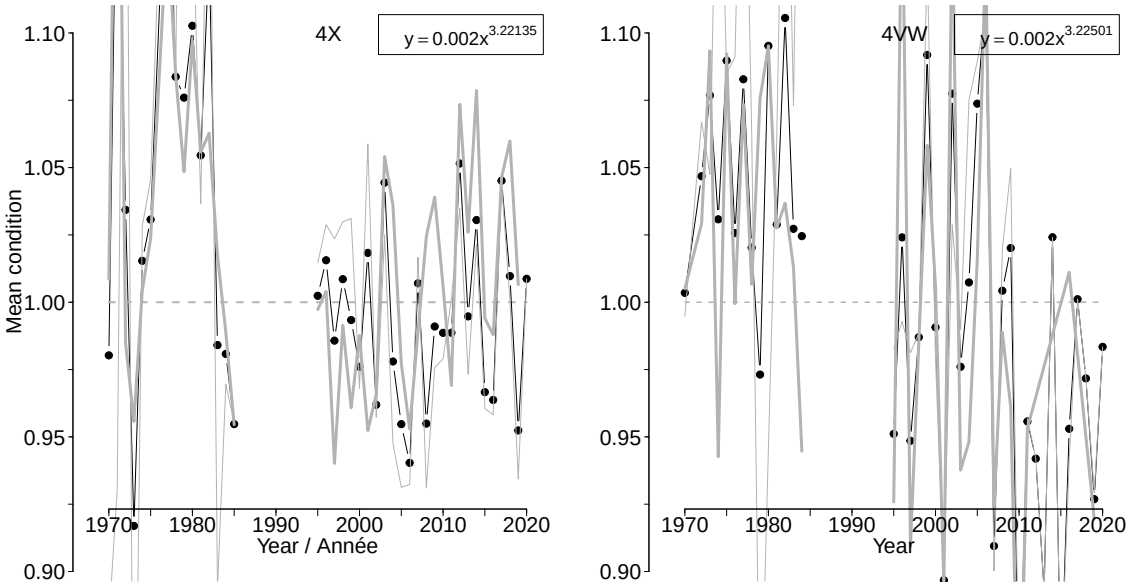
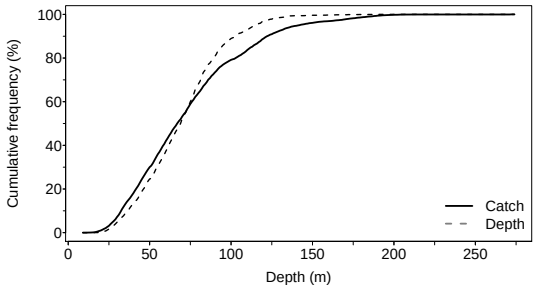
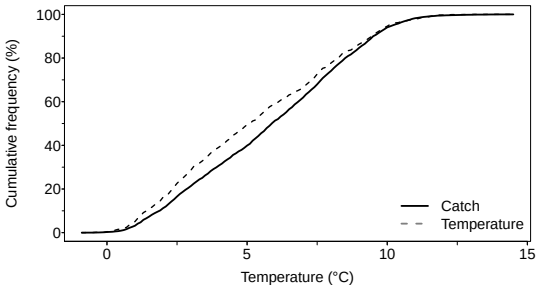
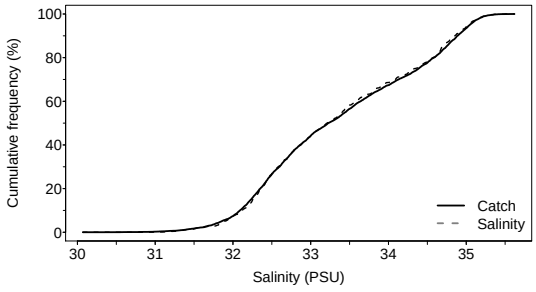


Figure 7.20D. Average fish condition in NAFO units 4X and 4VW for Ocean pout.



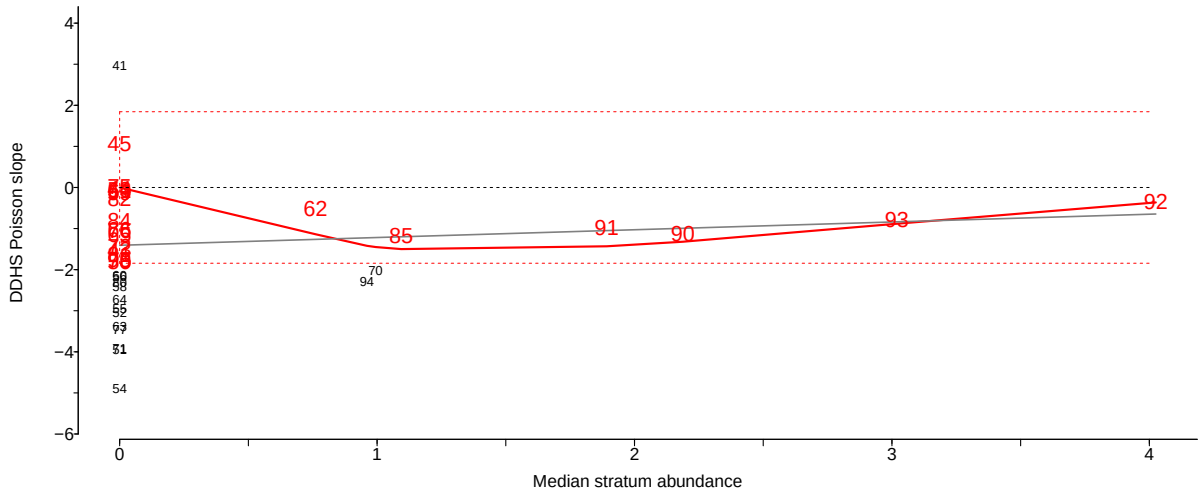


858



Freq	Depth	Temp	Sal
F5	31	1.0	31.00
F25	52	2.8	32.46
F50	69	5.1	33.22
F75	85	7.7	34.34
F95	116	10.0	35.03

Figure 7.20E. Catch distribution by depth, temperature and salinity of Ocean pout.



859

Figure 7.20F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Ocean pout.

7.21 Thorny skate (Raie épineuse) - species code 201 (category LF)

Scientific name: Amblyraja radiata

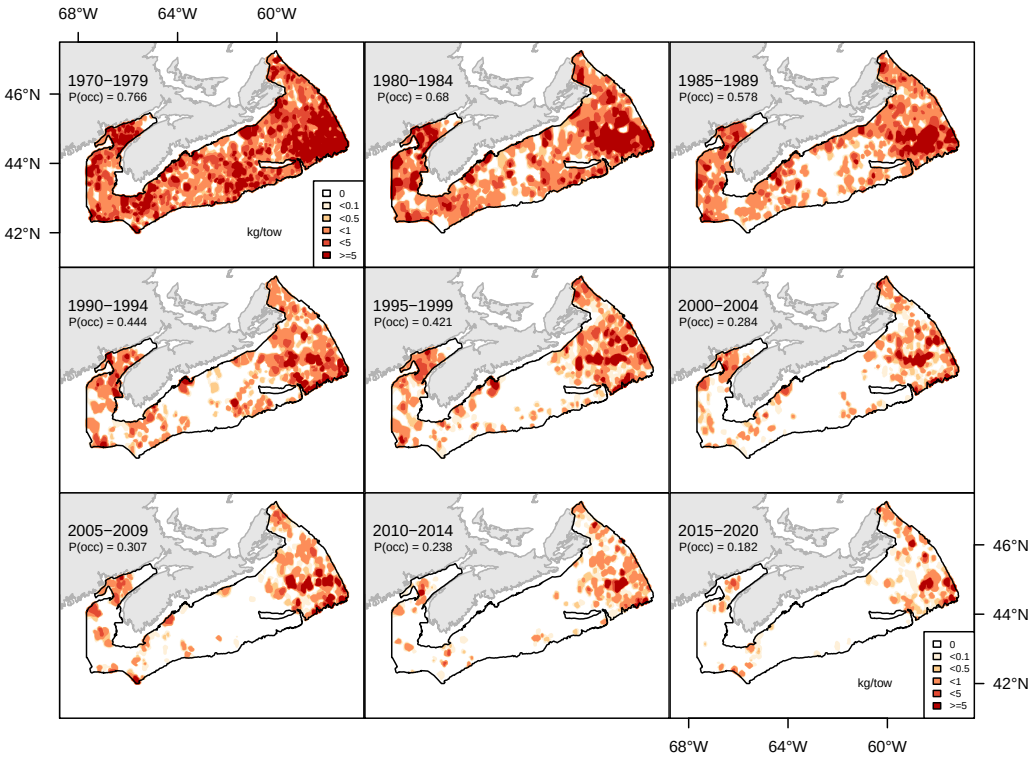


Figure 7.21A. Inverse distance weighted distribution of catch biomass (kg/tow) for Thorny skate.

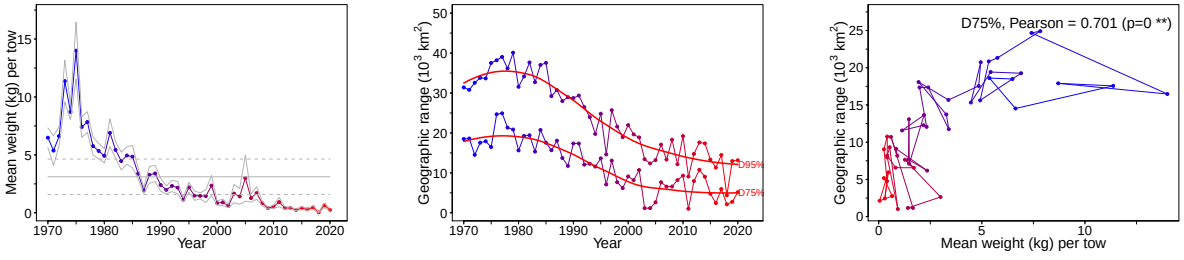


Figure 7.21B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Thorny skate.

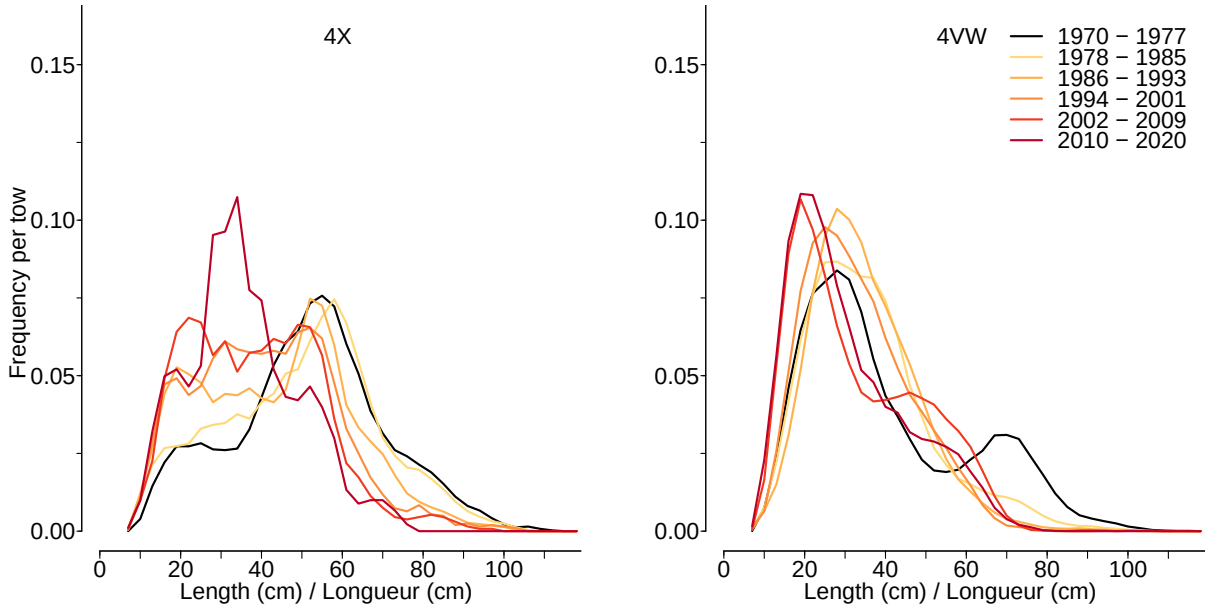


Figure 7.21C. Length frequency distribution in NAFO units 4X and 4VW for Thorny skate.

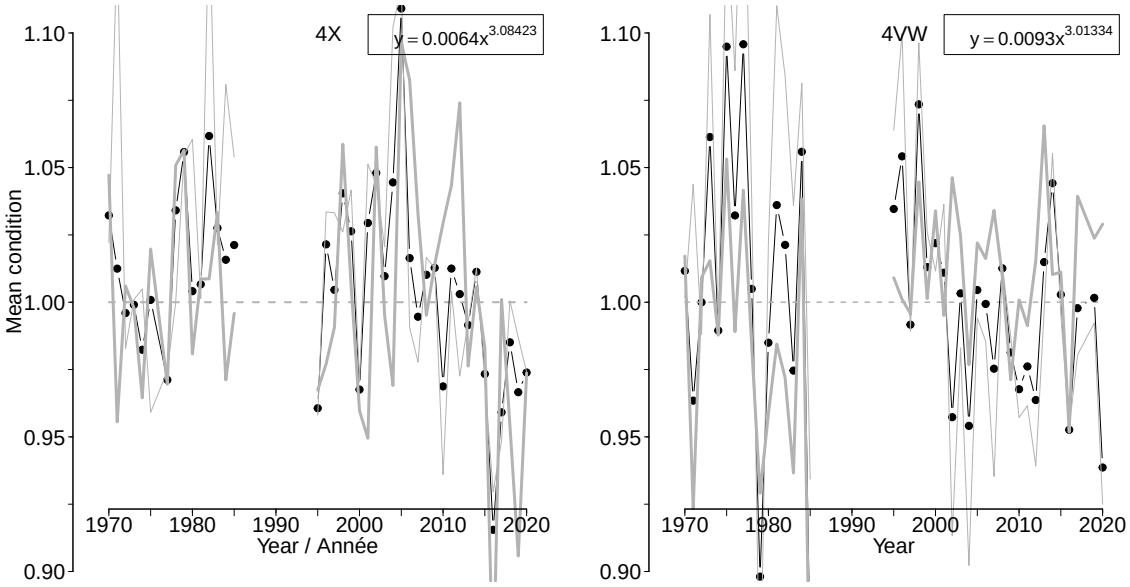
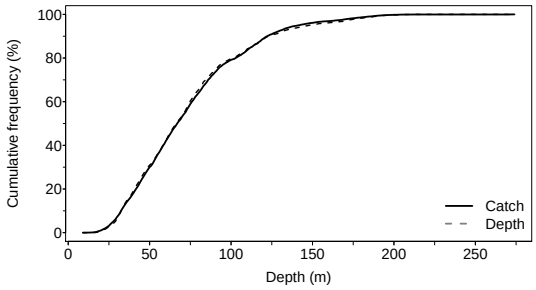
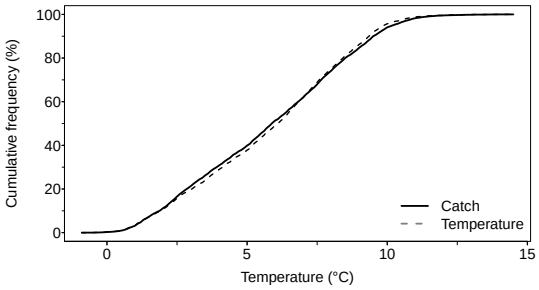
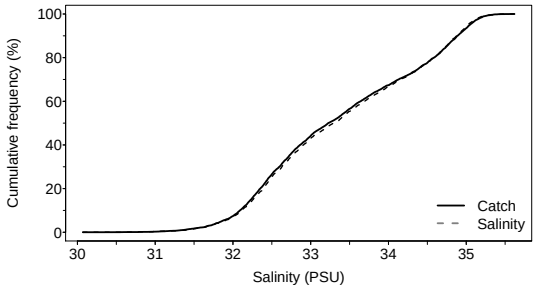


Figure 7.21D. Average fish condition in NAFO units 4X and 4VW for Thorny skate.



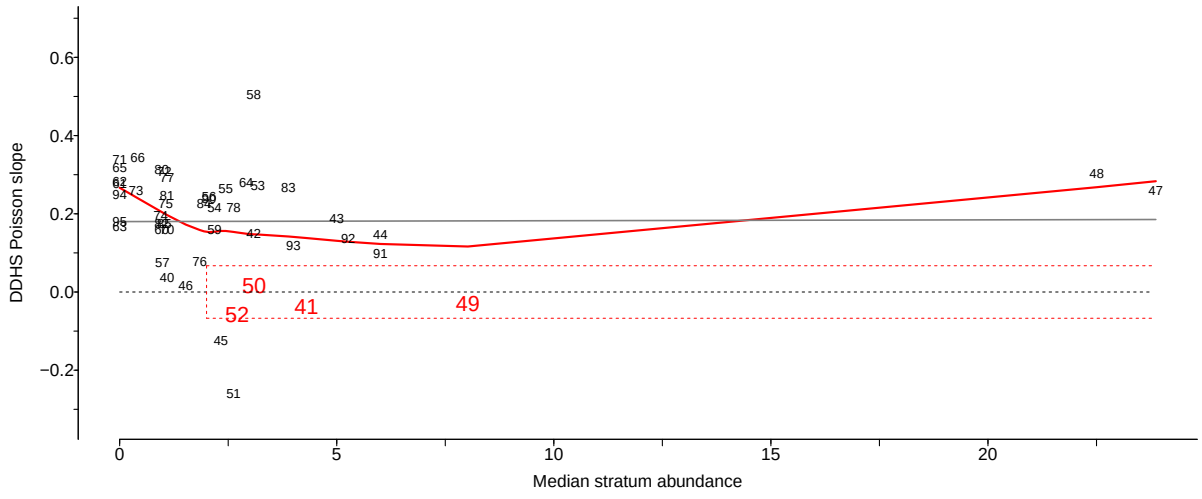


866



Freq	Depth	Temp	Sal
F5	29	1.3	31.00
F25	45	3.7	32.50
F50	67	6.2	33.30
F75	91	8.1	34.40
F95	148	9.9	35.03

Figure 7.21E. Catch distribution by depth, temperature and salinity of Thorny skate.



867

Figure 7.21F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Thorny skate.

7.22 Smooth skate (Raie lisse) - species code 202 (category LF)

Scientific name: Malacoraja senta

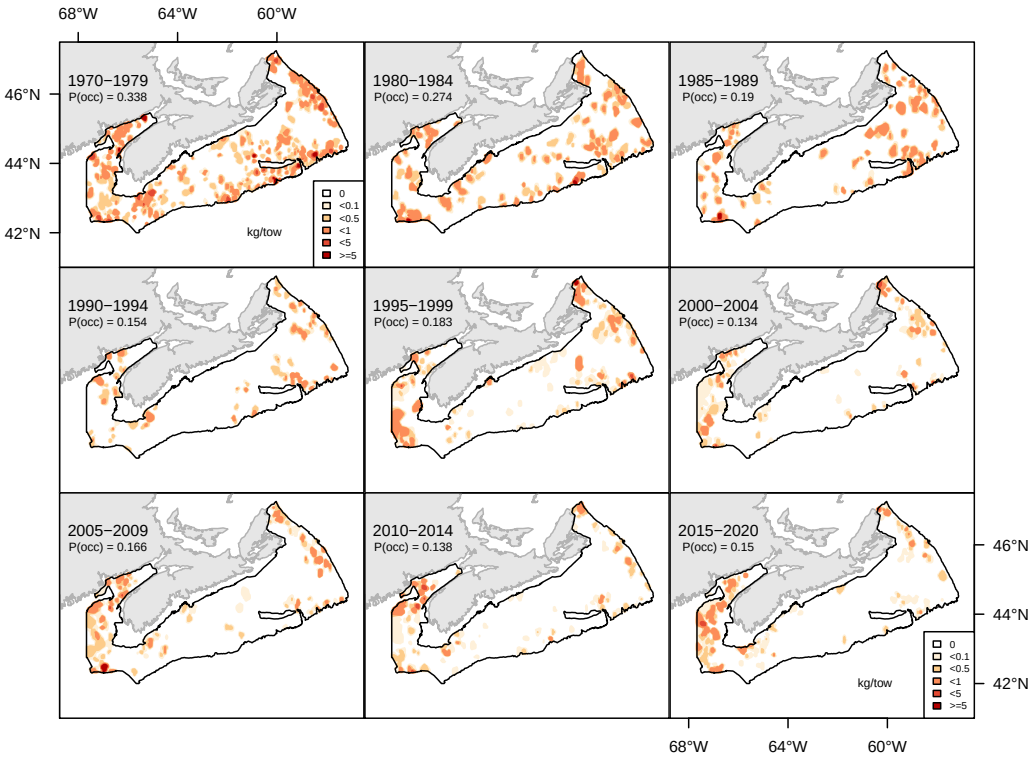


Figure 7.22A. Inverse distance weighted distribution of catch biomass (kg/tow) for Smooth skate.

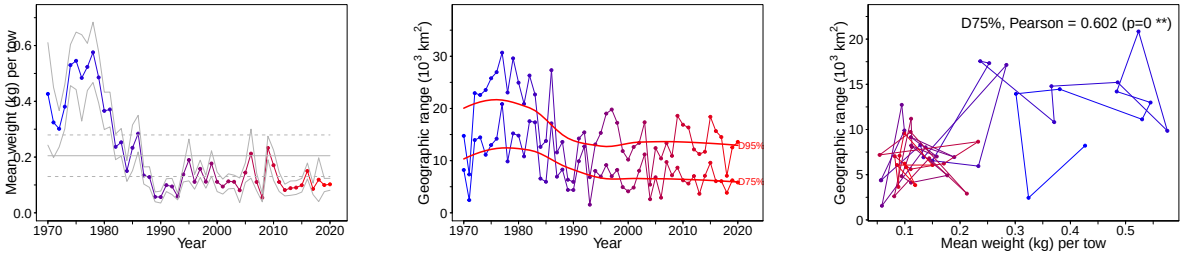


Figure 7.22B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Smooth skate.

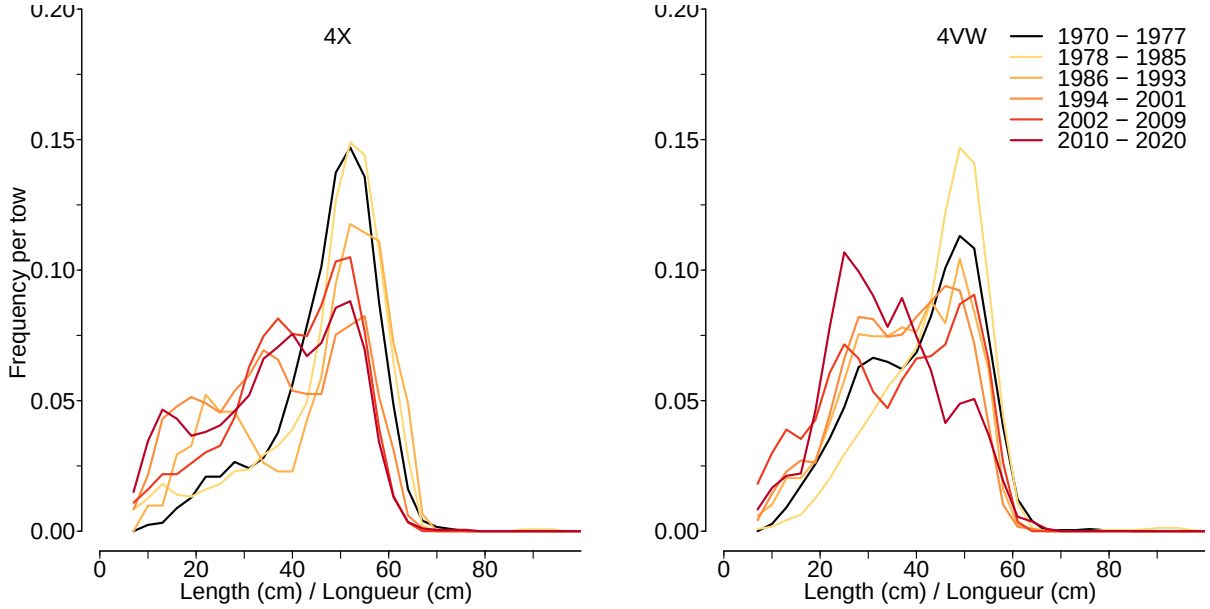


Figure 7.22C. Length frequency distribution in NAFO units 4X and 4VW for Smooth skate.

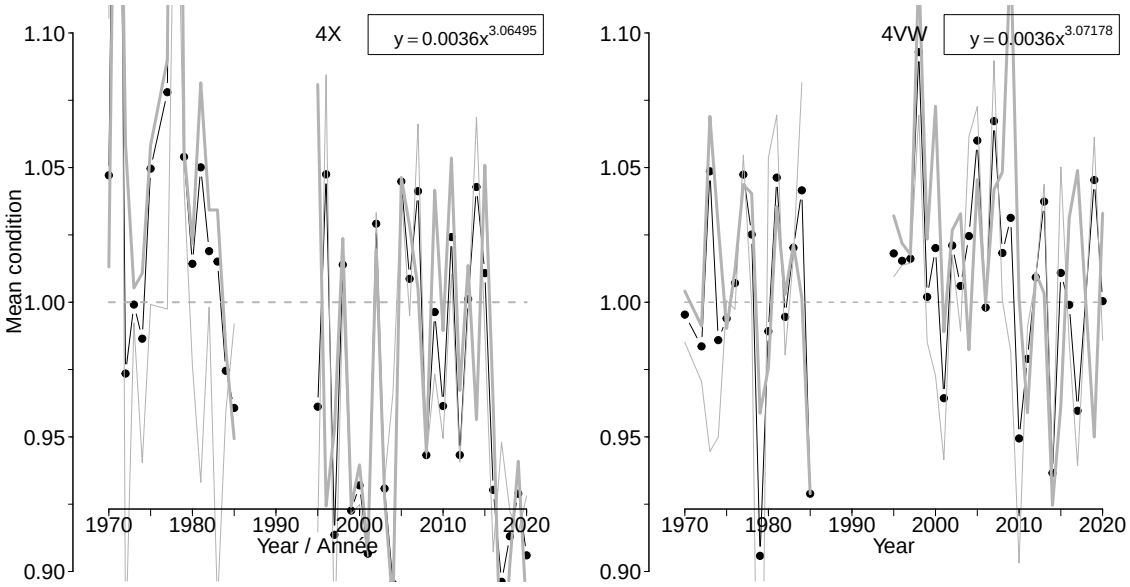
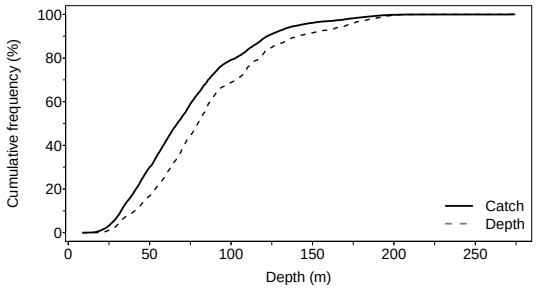
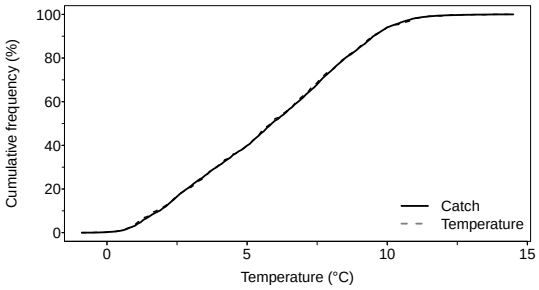
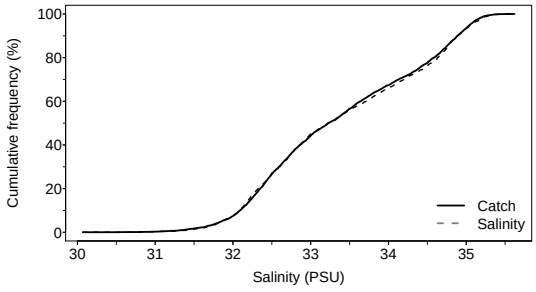


Figure 7.22D. Average fish condition in NAFO units 4X and 4VW for Smooth skate.







Freq	Depth	Temp	Sal
F5	33	1.2	31.00
F25	59	3.5	32.47
F50	80	5.9	33.23
F75	110	8.1	34.45
F95	171	10.0	35.06

Figure 7.22E. Catch distribution by depth, temperature and salinity of Smooth skate.

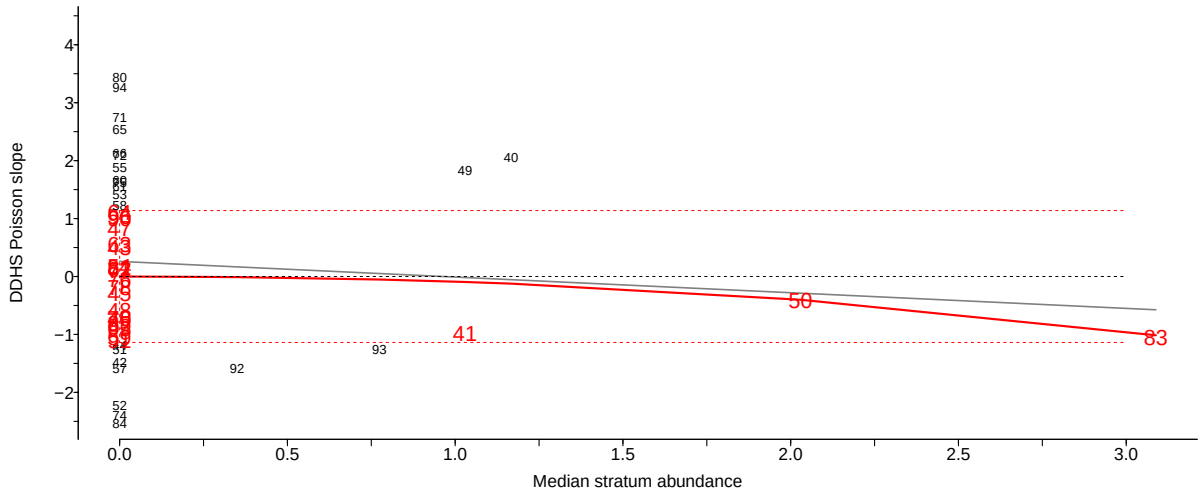


Figure 7.22F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Smooth skate.

7.23 Winter skate (Raie tachetée) - species code 204 (category LF)

Scientific name: Leucoraja ocellata

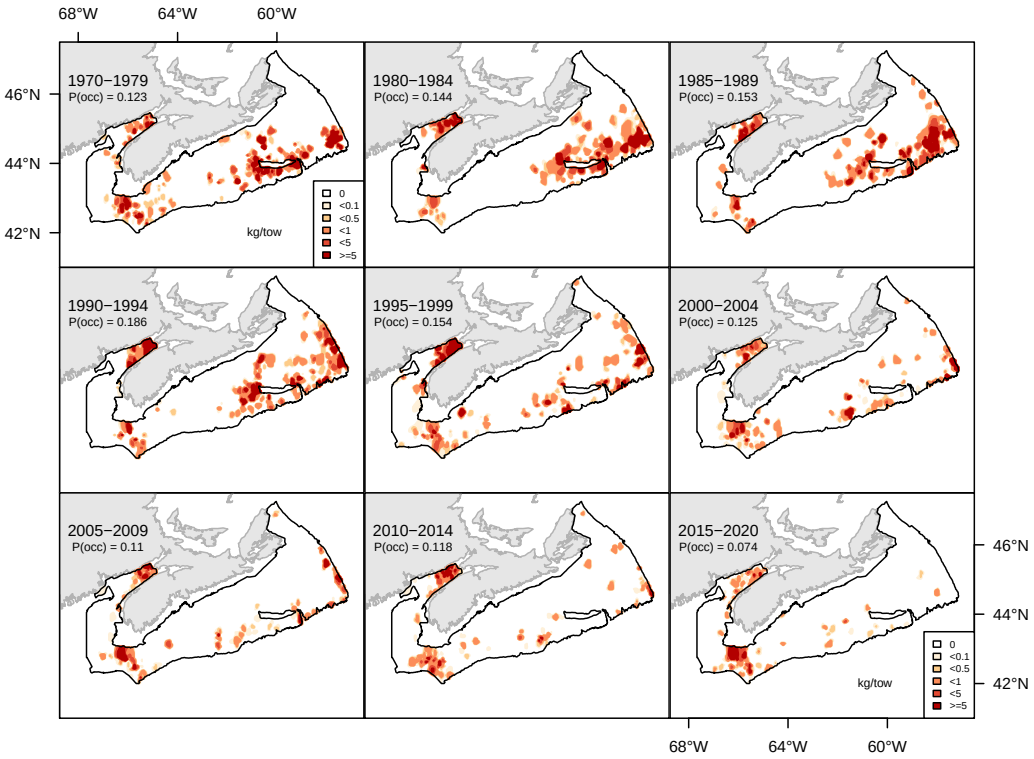


Figure 7.23A. Inverse distance weighted distribution of catch biomass (kg/tow) for Winter skate.

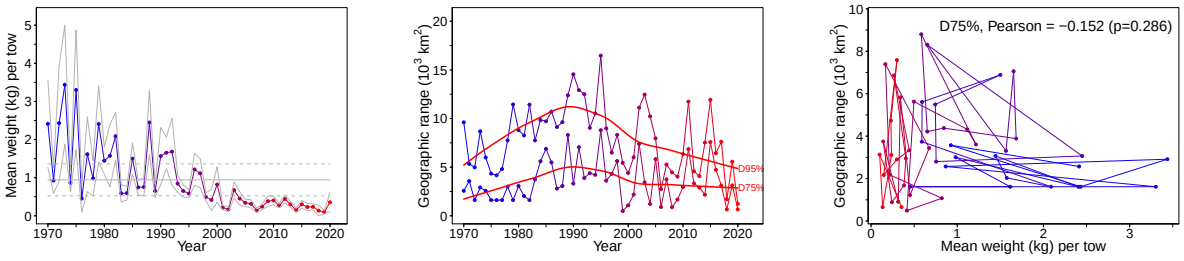


Figure 7.23B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Winter skate.

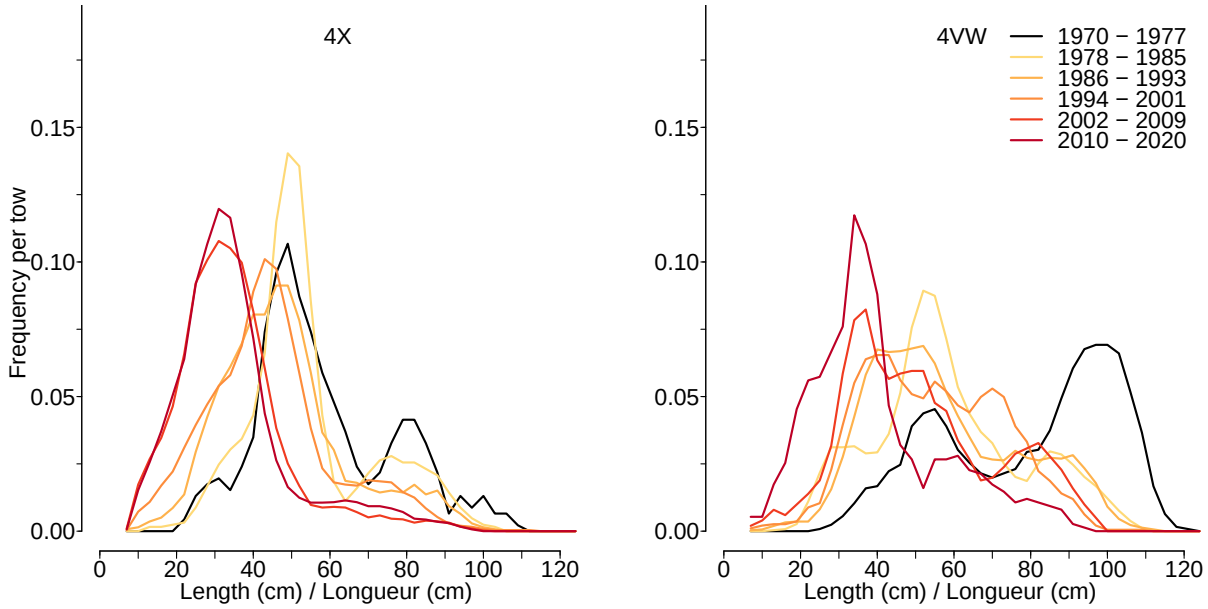


Figure 7.23C. Length frequency distribution in NAFO units 4X and 4VW for Winter skate.

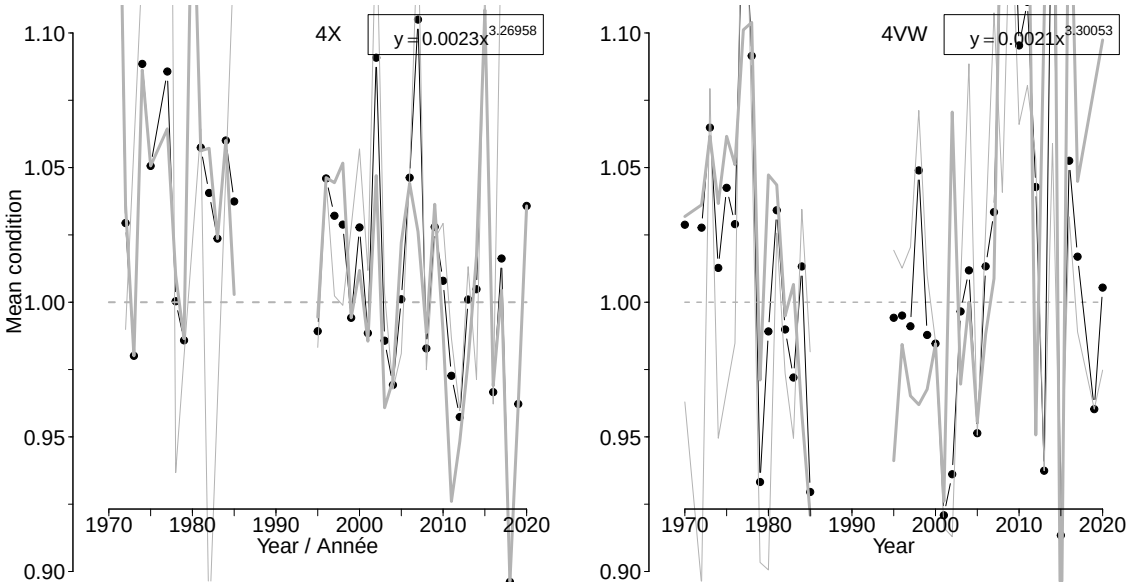
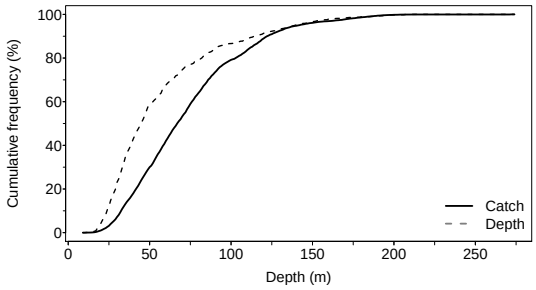
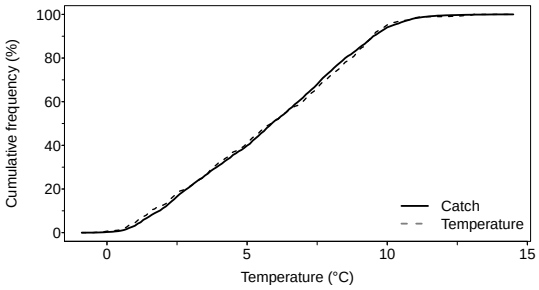
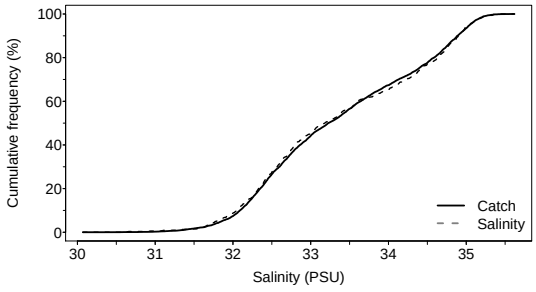


Figure 7.23D. Average fish condition in NAFO units 4X and 4VW for Winter skate.



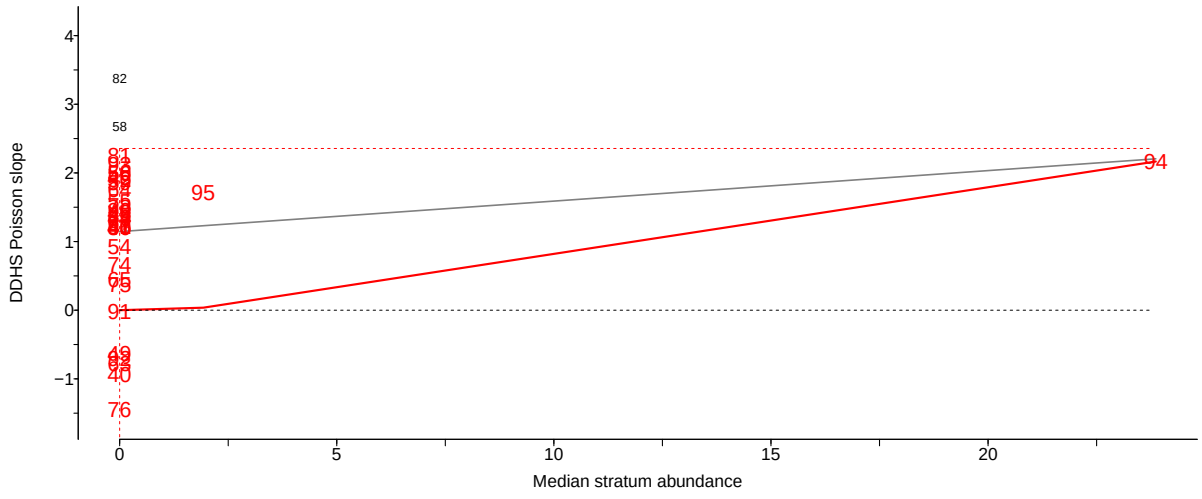


882



Freq	Depth	Temp	Sal
F5	21	1.1	31.00
F25	32	3.5	32.44
F50	45	5.9	33.19
F75	71	8.3	34.42
F95	140	10.0	35.03

Figure 7.23E. Catch distribution by depth, temperature and salinity of Winter skate.



883

Figure 7.23F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Winter skate.

7.24 Picked dogfish (Aiguillat commun) - species code 220 (category LF)

Scientific name: Squalus acanthias

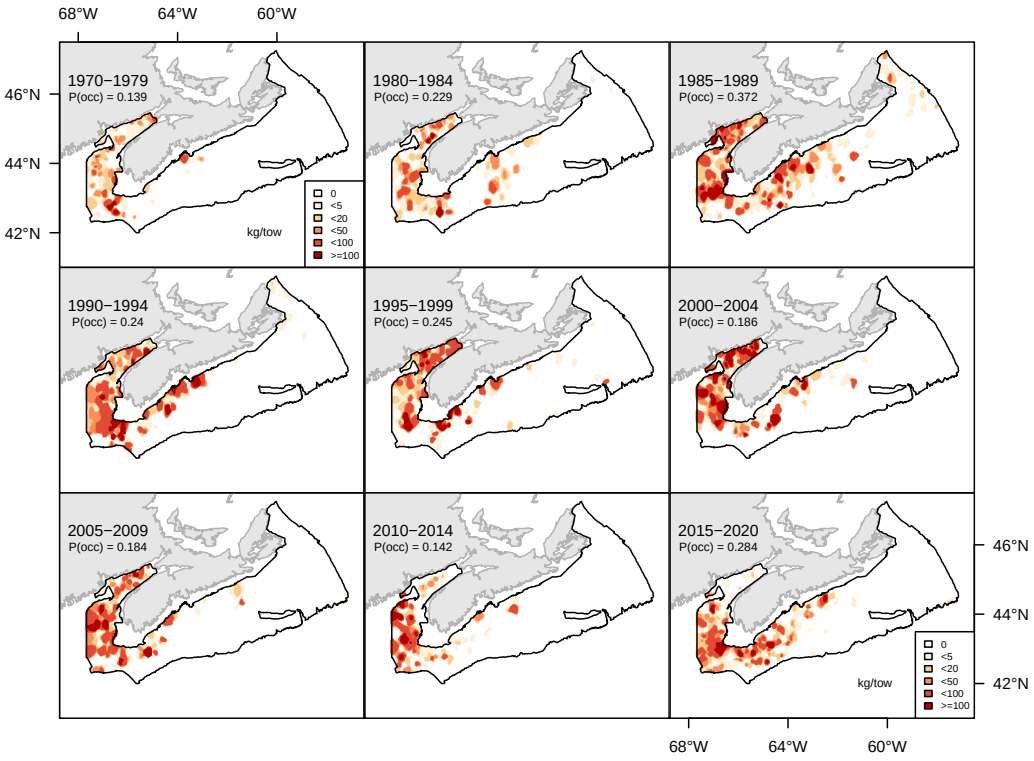


Figure 7.24A. Inverse distance weighted distribution of catch biomass (kg/tow) for Picked dogfish.

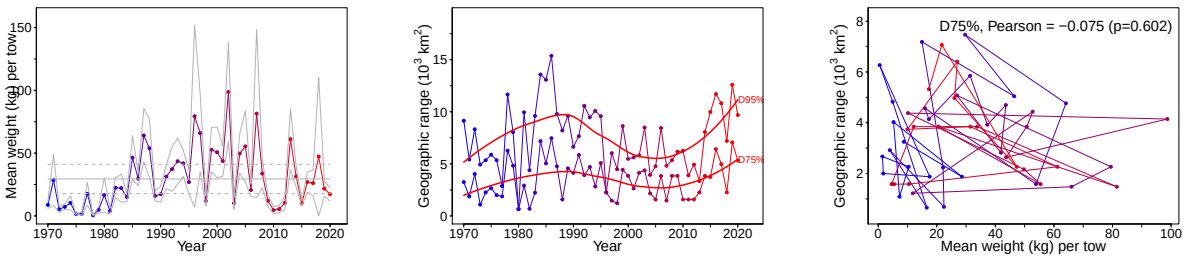


Figure 7.24B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Picked dogfish.

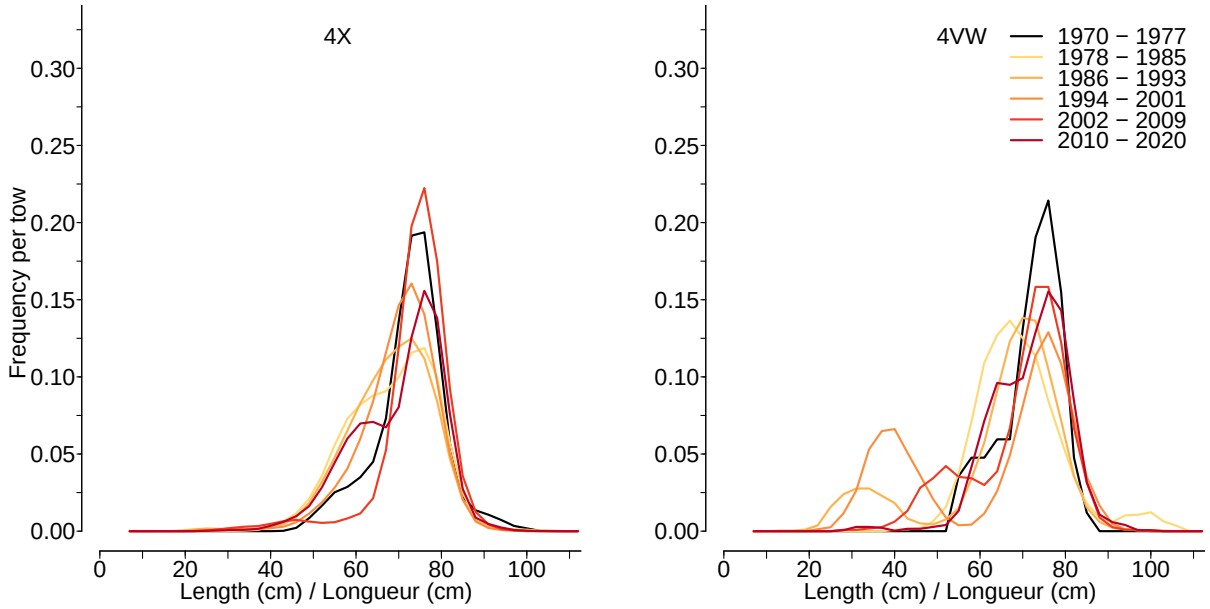


Figure 7.24C. Length frequency distribution in NAFO units 4X and 4VW for Picked dogfish.

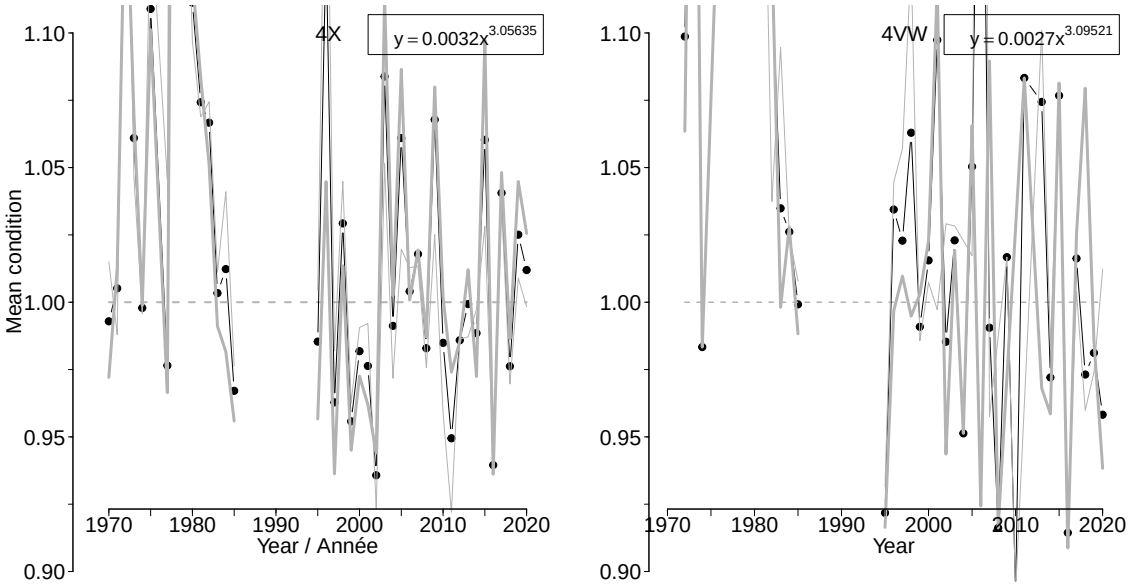
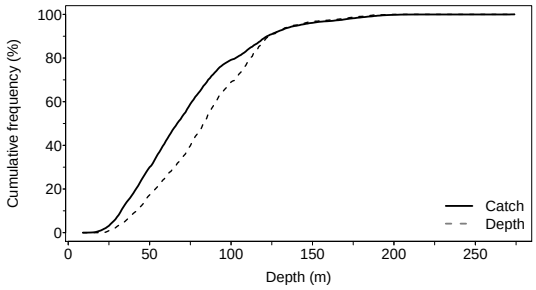
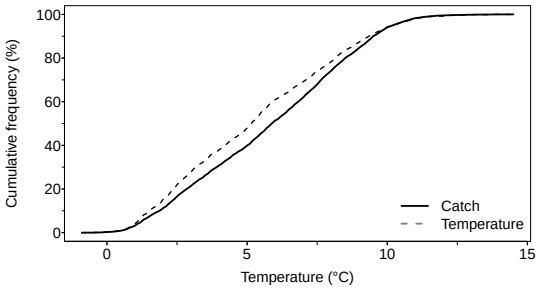
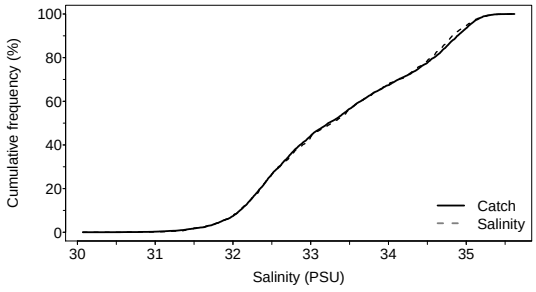


Figure 7.24D. Average fish condition in NAFO units 4X and 4VW for Picked dogfish.







Freq	Depth	Temp	Sal
F5	35	1.1	31.00
F25	60	2.8	32.47
F50	83	5.2	33.28
F75	108	7.7	34.37
F95	139	10.0	35.02

Figure 7.24E. Catch distribution by depth, temperature and salinity of Picked dogfish.

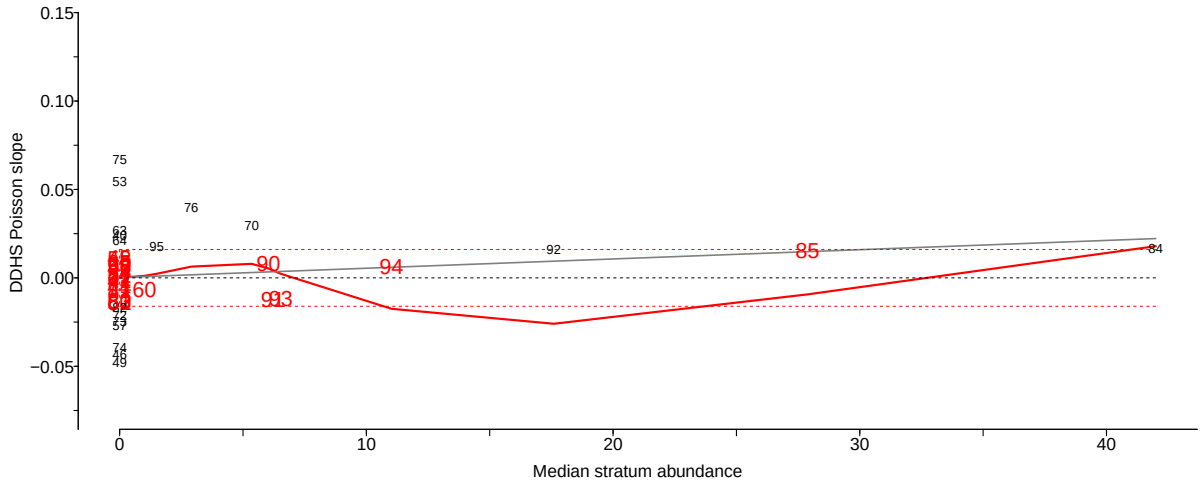


Figure 7.24F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Picked dogfish.

7.25 Northern shortfin squid (Encornet rouge nordique) - species code 4511 (category LF)

Scientific name: Illex illecebrosus

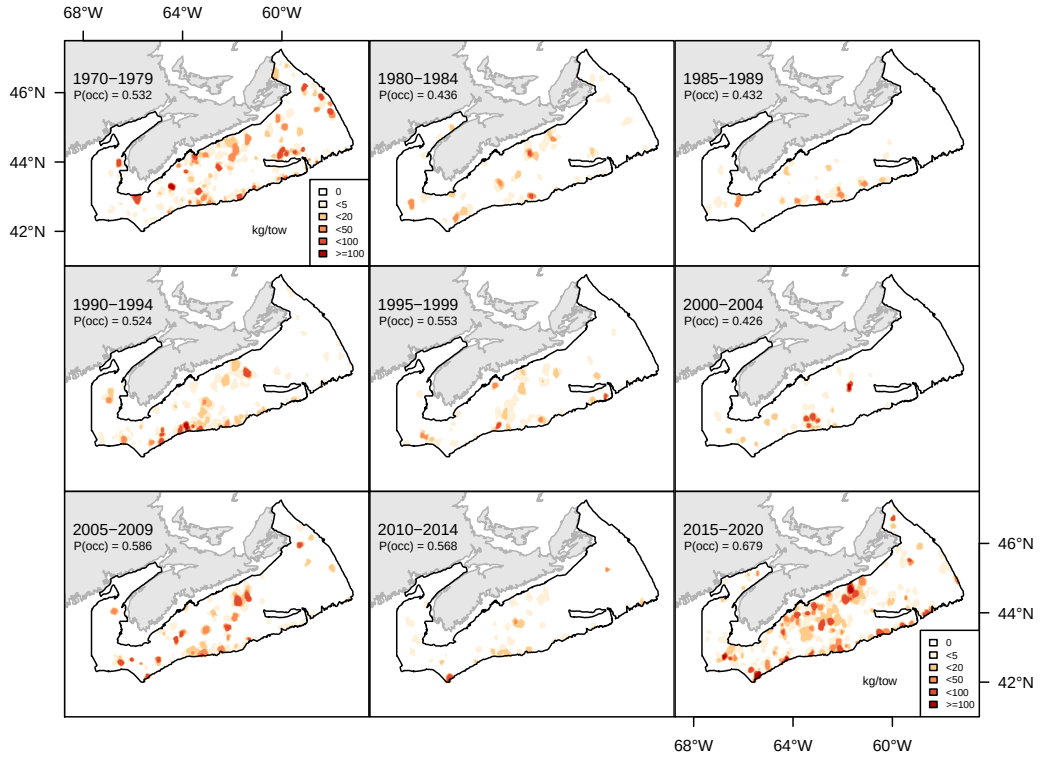


Figure 7.25A. Inverse distance weighted distribution of catch biomass (kg/tow) for Northern shortfin squid.

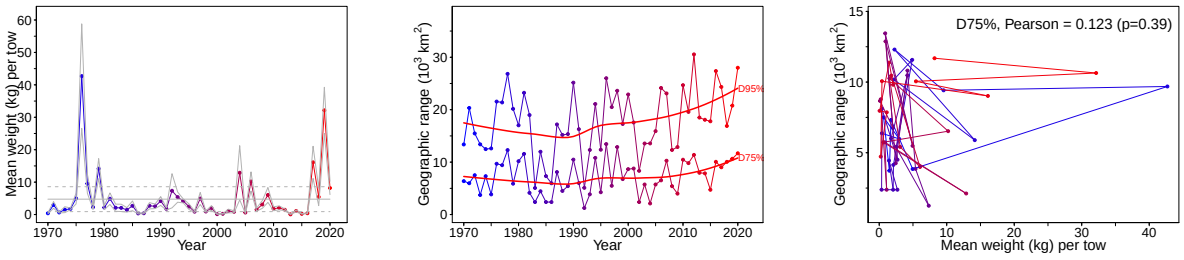


Figure 7.25B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Northern shortfin squid.

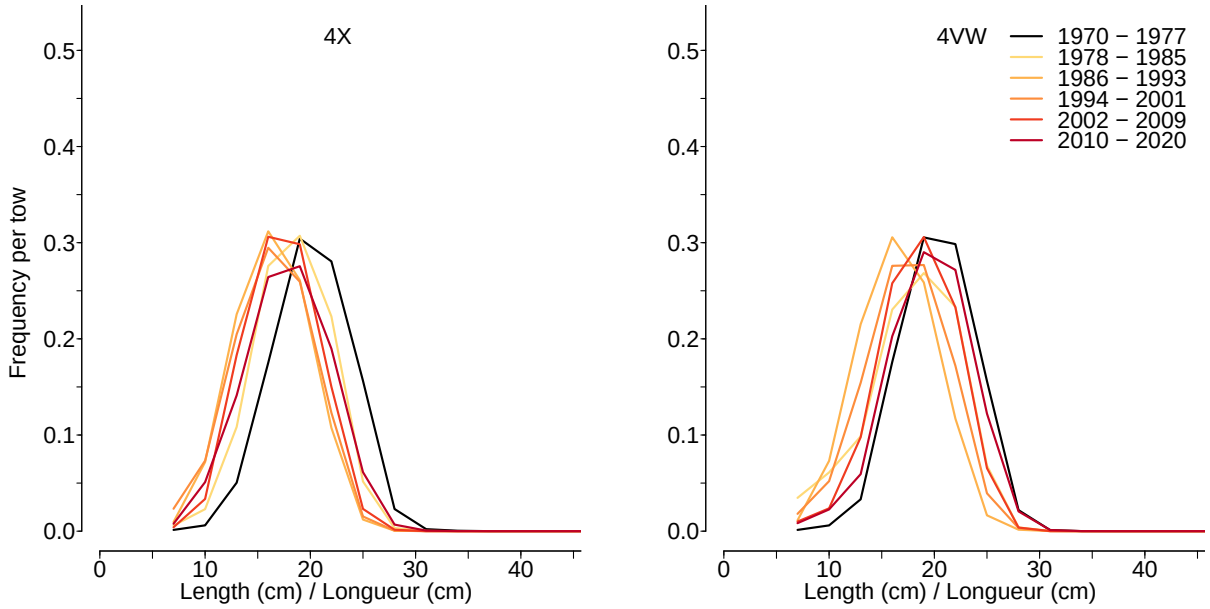


Figure 7.25C. Length frequency distribution in NAFO units 4X and 4VW for Northern shortfin squid.

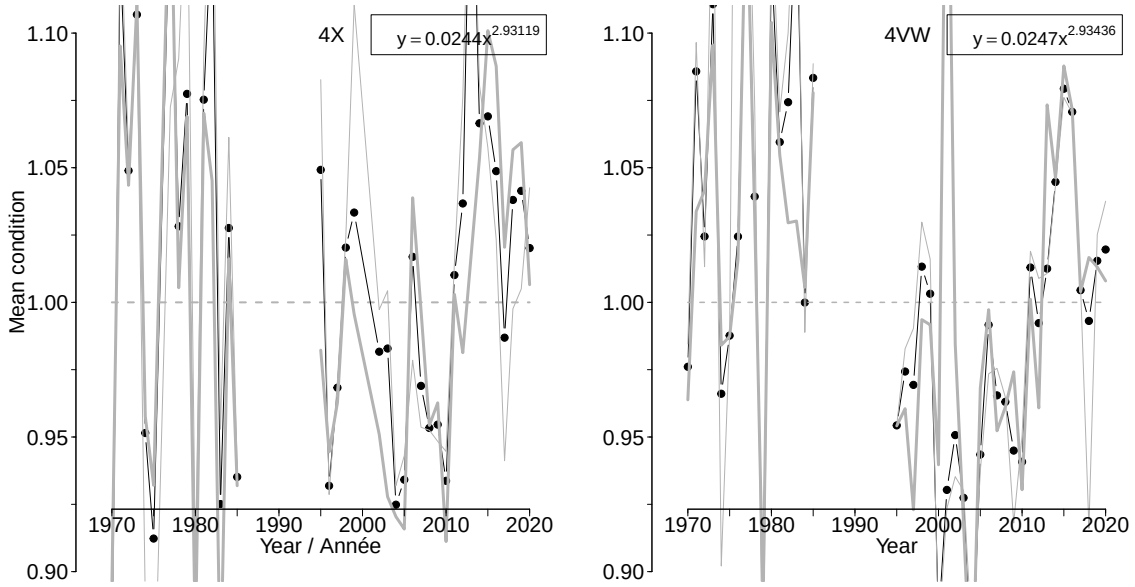
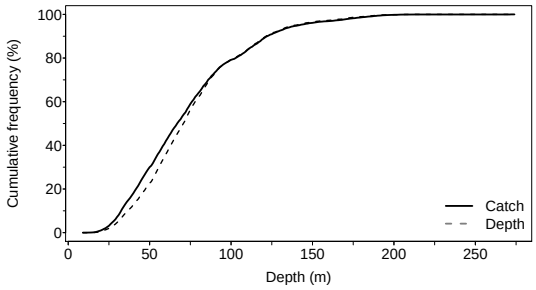
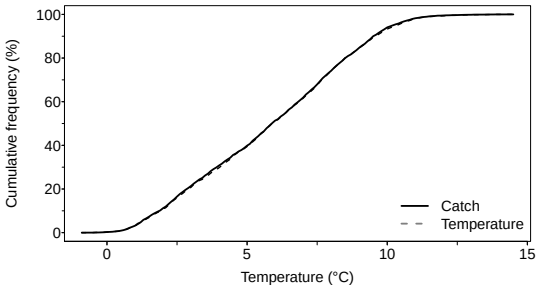
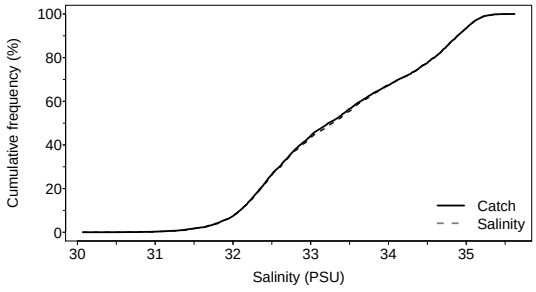


Figure 7.25D. Average fish condition in NAFO units 4X and 4VW for Northern shortfin squid.







Freq	Depth	Temp	Sal
F5	31	1.3	31.00
F25	53	3.5	32.48
F50	71	5.9	33.28
F75	93	8.1	34.39
F95	139	10.0	35.05

Figure 7.25E. Catch distribution by depth, temperature and salinity of Northern shortfin squid.

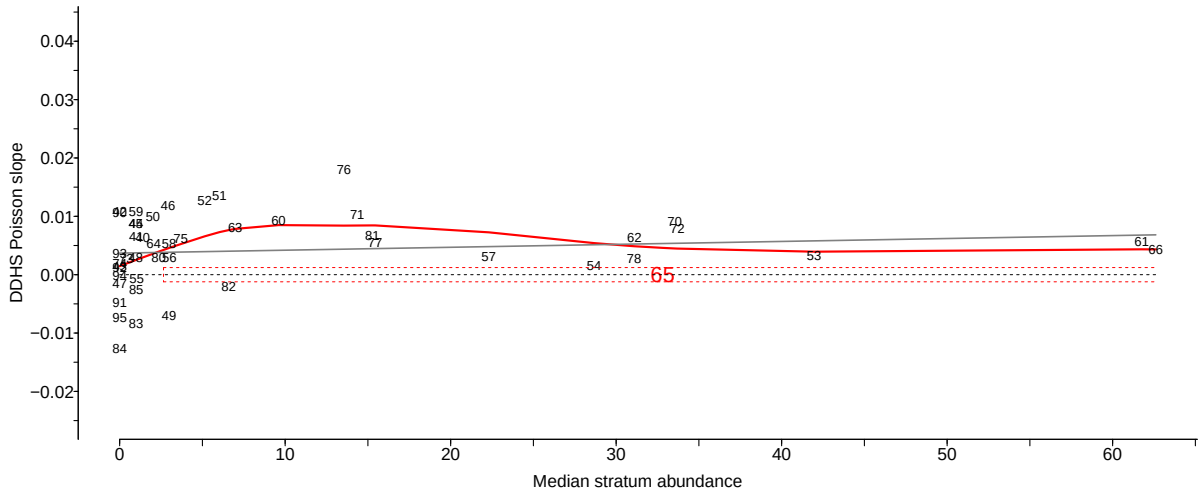


Figure 7.25F. DDHS slopes versus median stratum abundance. The last two digits of each stratum number is shown in the figure for Northern shortfin squid.

7.26 Atlantic hagfish (Myxine du nord) - species code 241 (category LI)

Scientific name: Myxine glutinosa

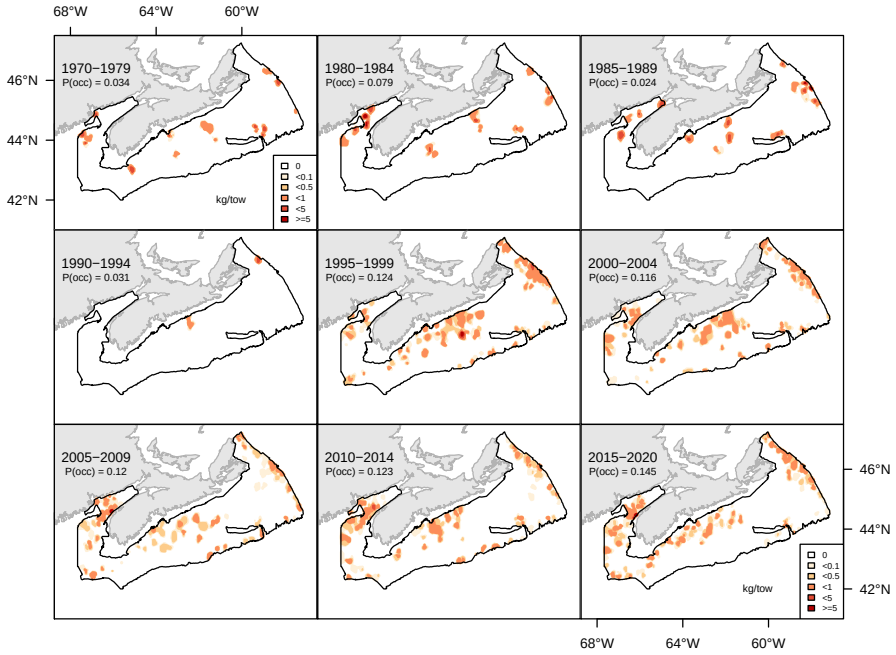


Figure 7.26A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic hagfish.

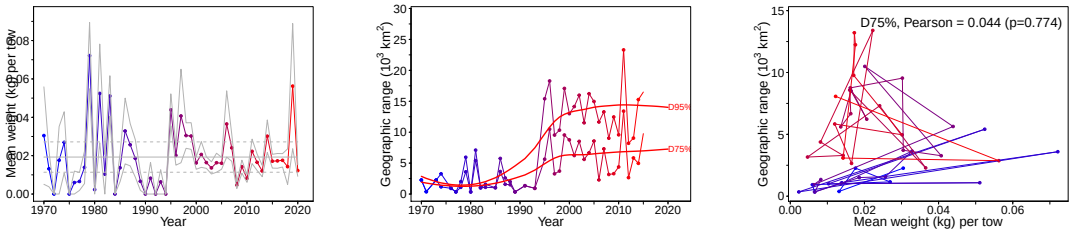


Figure 7.26B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic hagfish.

7.27 Cusk (Brosme) - species code 15 (category LI)

Scientific name: Brosme brosme

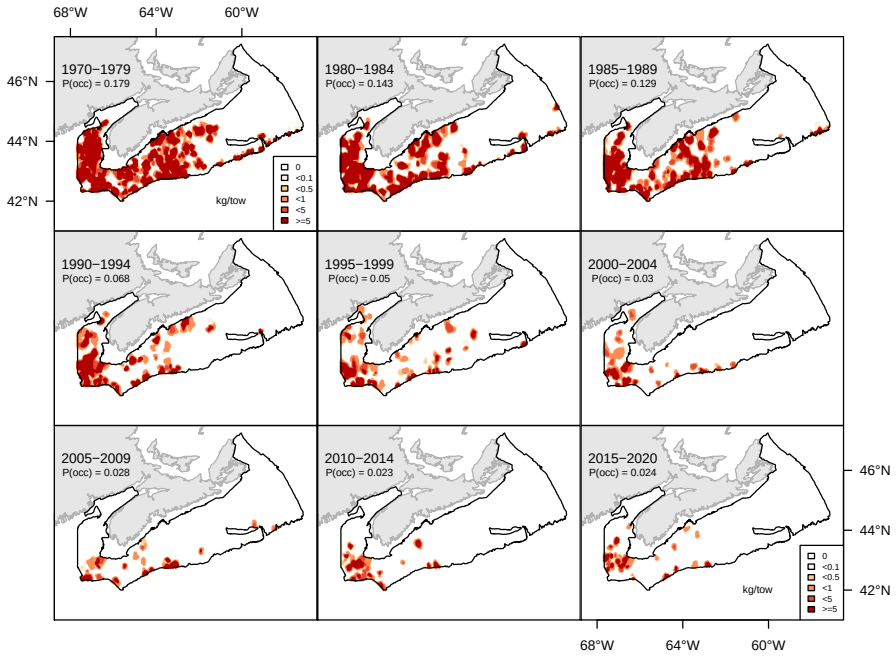


Figure 7.27A. Inverse distance weighted distribution of catch biomass (kg/tow) for Cusk.

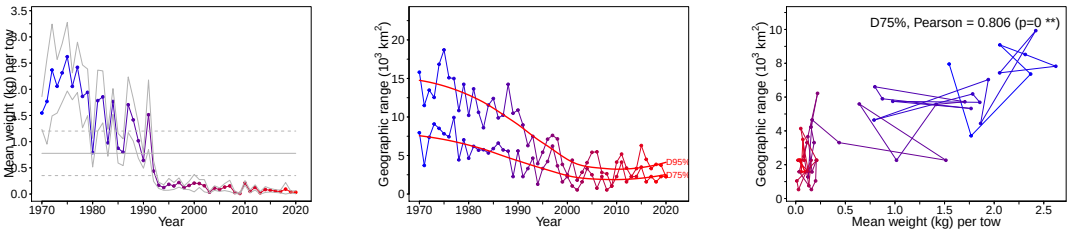


Figure 7.27B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Cusk.

7.28 Greenland halibut (Flétan noir) - species code 31 (category LI)

Scientific name: Reinhardtius hippoglossoides

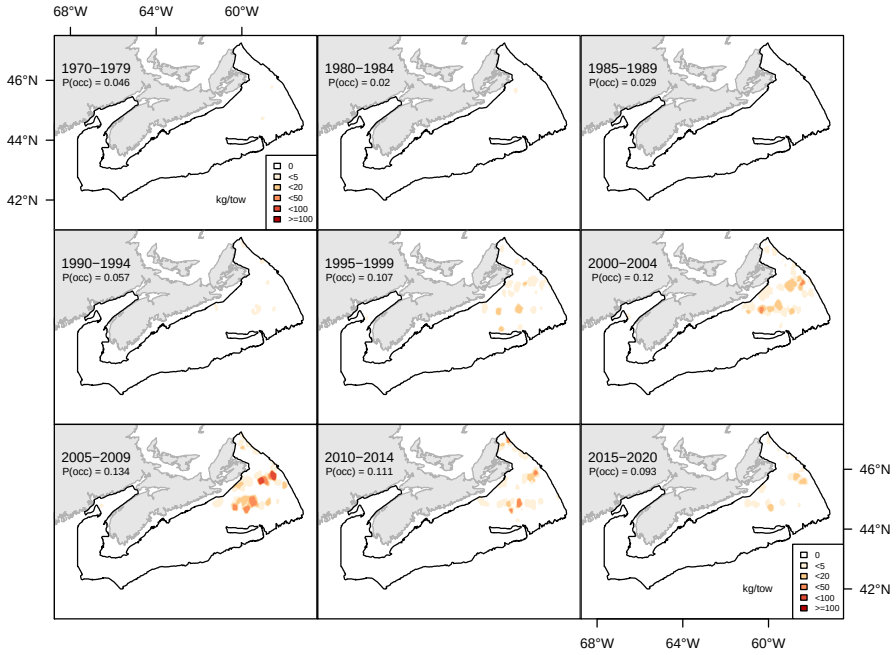


Figure 7.28A. Inverse distance weighted distribution of catch biomass (kg/tow) for Greenland halibut.

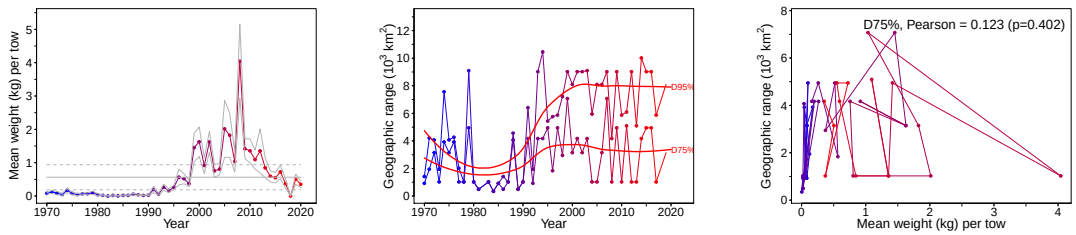


Figure 7.28B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Greenland halibut.

7.29 Gulf Stream flounder (Plie du Gulf Stream) - species code 44 (category LI)

Scientific name: Citharichthys arctifrons

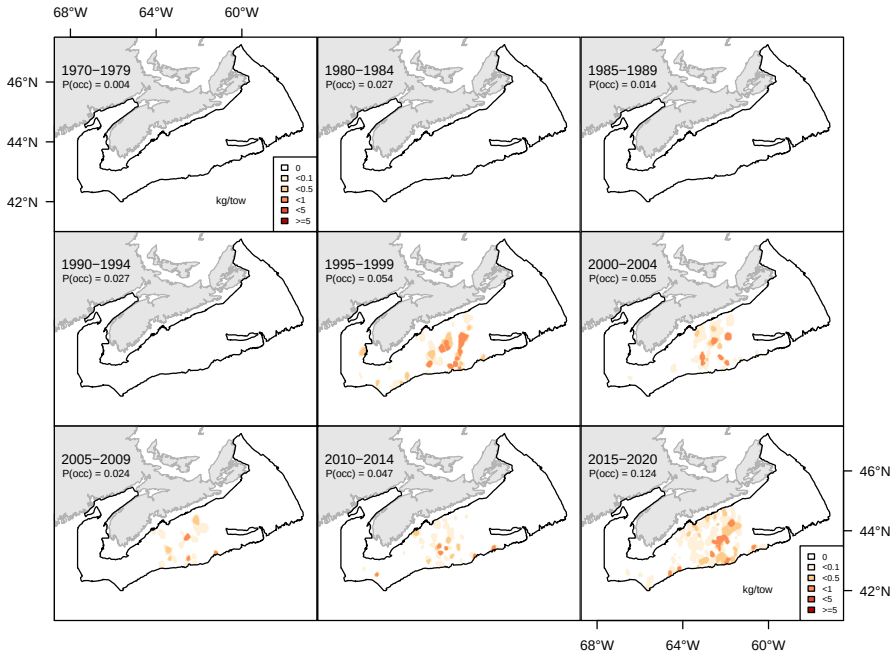


Figure 7.29A. Inverse distance weighted distribution of catch biomass (kg/tow) for Gulf Stream flounder.

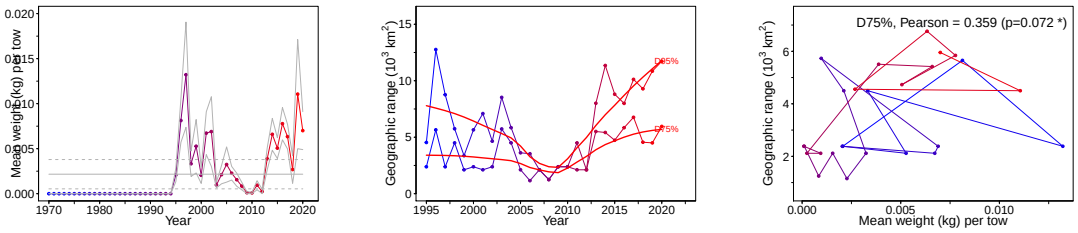


Figure 7.29B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Gulf Stream flounder.

7.30 American shad (Alose savoureuse) - species code 61 (category LI)

Scientific name: Alosa sapidissima

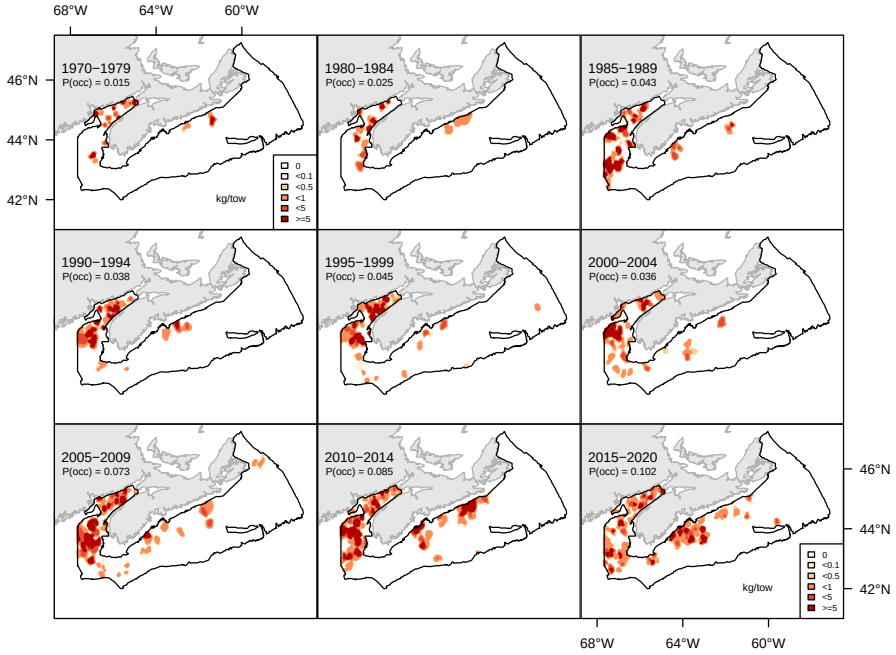


Figure 7.30A. Inverse distance weighted distribution of catch biomass (kg/tow) for American shad.

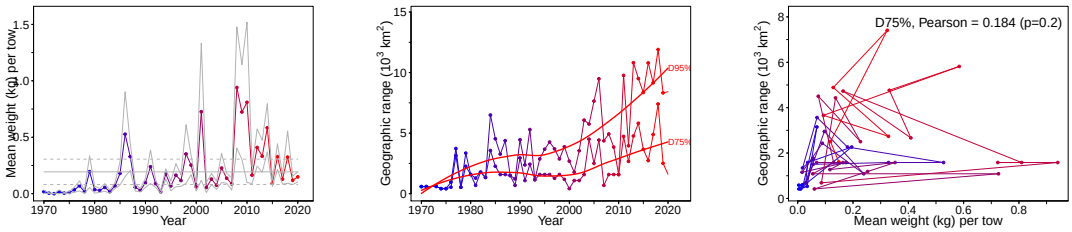


Figure 7.30B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American shad.

7.31 Alewife (Gaspareau) - species code 62 (category LI)

Scientific name: Alosa pseudoharengus

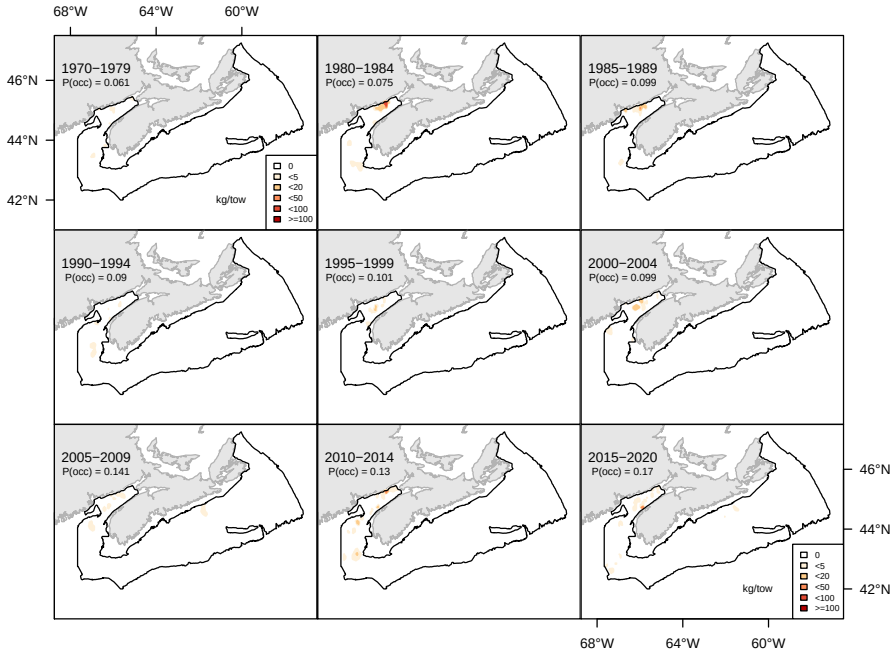


Figure 7.31A. Inverse distance weighted distribution of catch biomass (kg/tow) for Alewife.

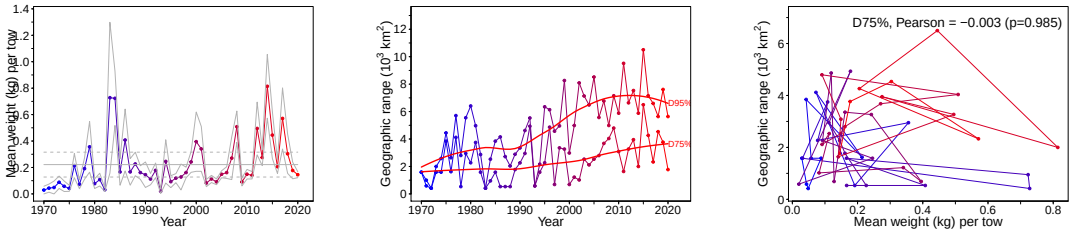


Figure 7.31B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Alewife.

7.32 Capelin (Capelan) - species code 64 (category LI)

Scientific name: Mallotus villosus

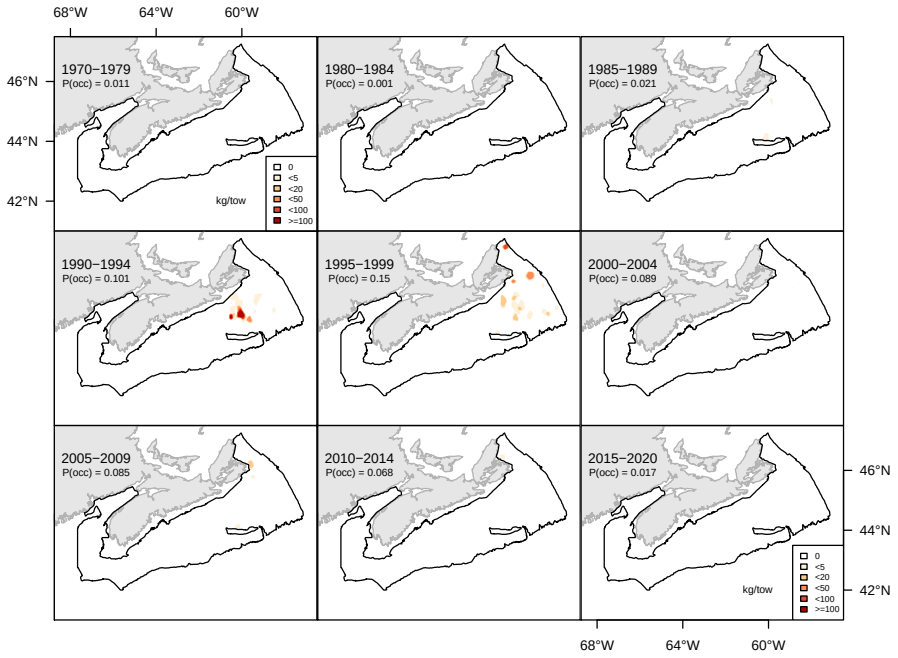


Figure 7.32A. Inverse distance weighted distribution of catch biomass (kg/tow) for Capelin.

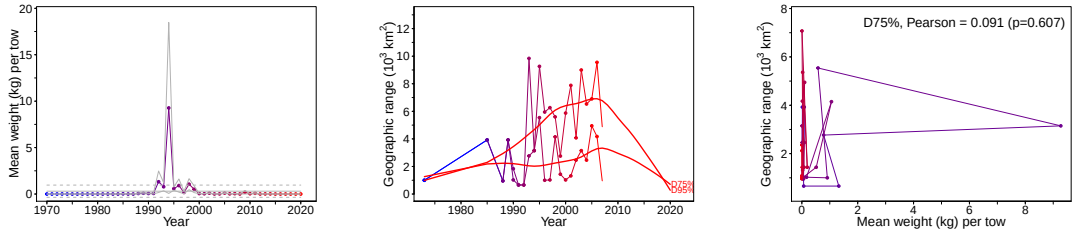


Figure 7.32B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Capelin.

7.33 Atlantic mackerel (Maquereau commun) - species code 70 (category LI)

Scientific name: Scomber scombrus

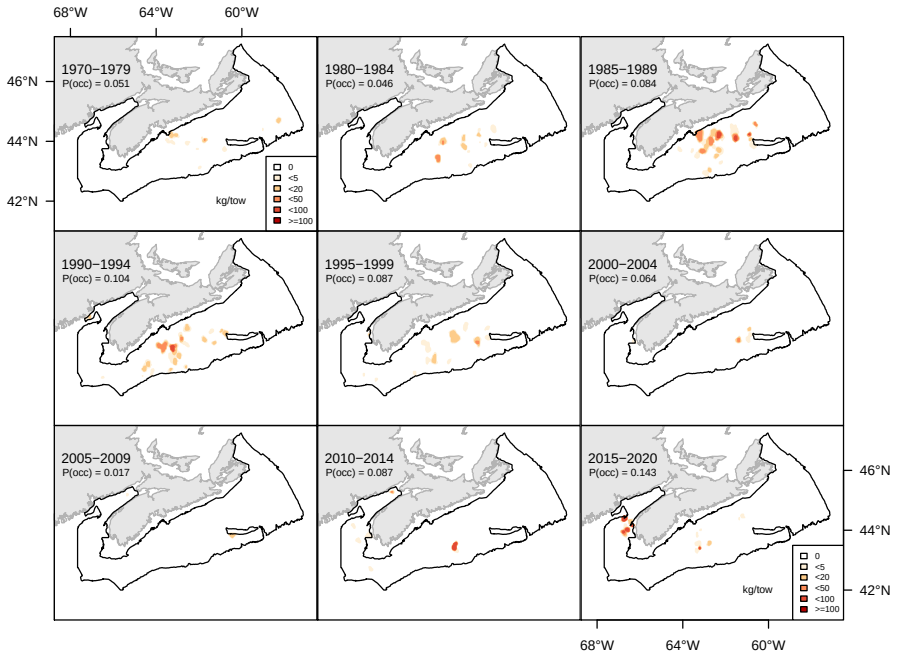


Figure 7.33A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic mackerel.

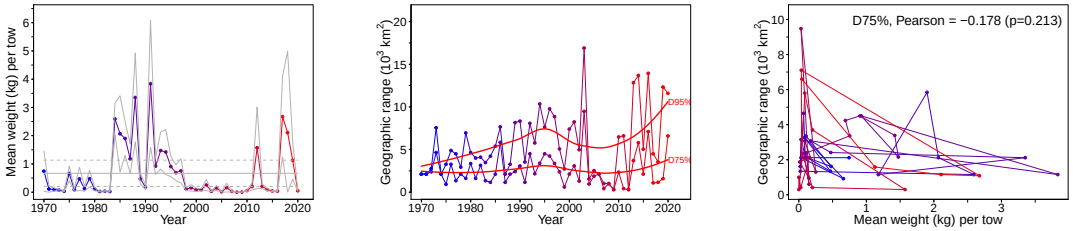


Figure 7.33B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic mackerel.

7.34 Longfin hake (Merluche à longues nageoires) - species code 112 (category LI)

Scientific name: Phycis chesteri

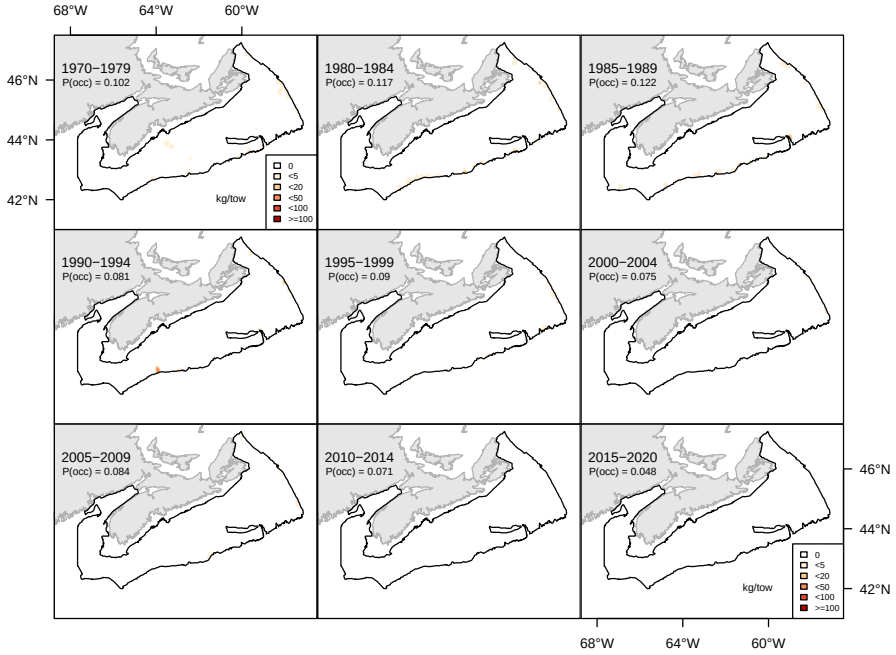


Figure 7.34A. Inverse distance weighted distribution of catch biomass (kg/tow) for Longfin hake.

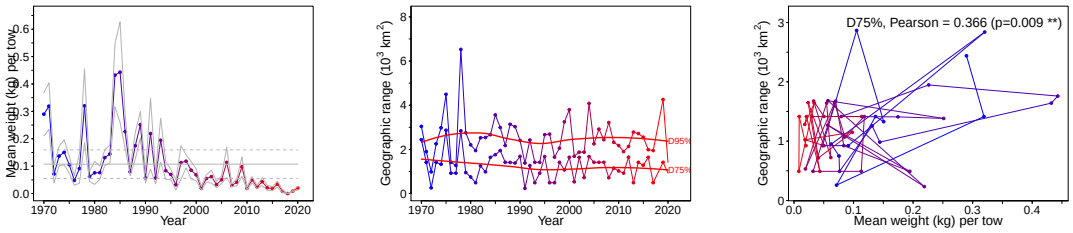


Figure 7.34B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Longfin hake.

7.35 Fourbeard rockling (Motelle à quatre barbillons) - species code 114 (category LI)

Scientific name: Enchelyopus cimbrius

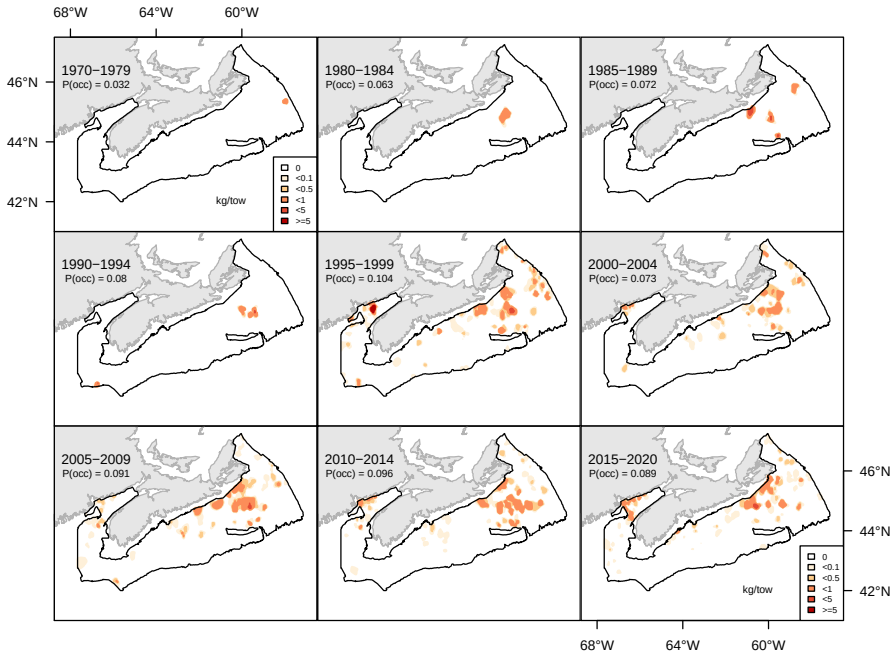


Figure 7.35A. Inverse distance weighted distribution of catch biomass (kg/tow) for Fourbeard rockling.

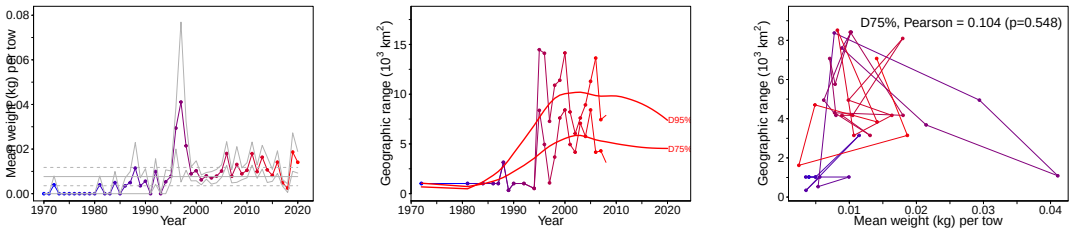


Figure 7.35B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Fourbeard rockling.

7.36 Blackbelly rosefish (Sébaste chèvre) - species code 123 (category LI)

Scientific name: Helicolenus dactylopterus

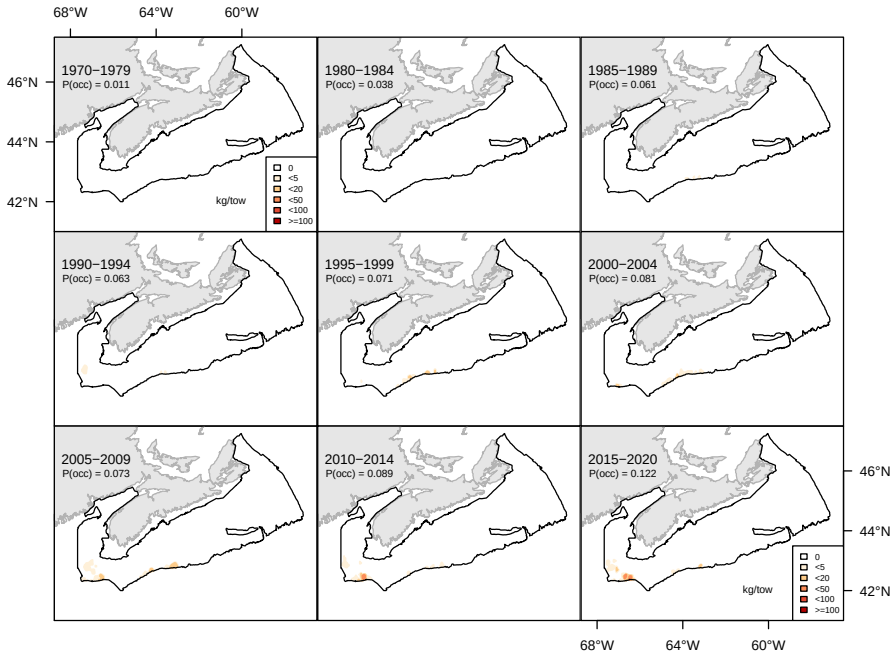


Figure 7.36A. Inverse distance weighted distribution of catch biomass (kg/tow) for Blackbelly rosefish.

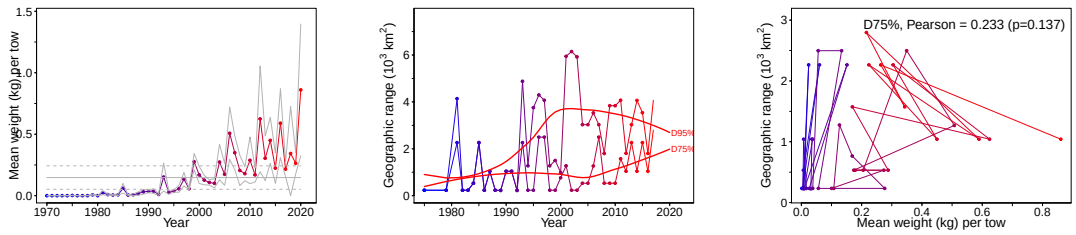


Figure 7.36B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Blackbelly rosefish.

7.37 Greater argentine (Grande argentine) - species code 160 (category LI)

Scientific name: Argentina silus

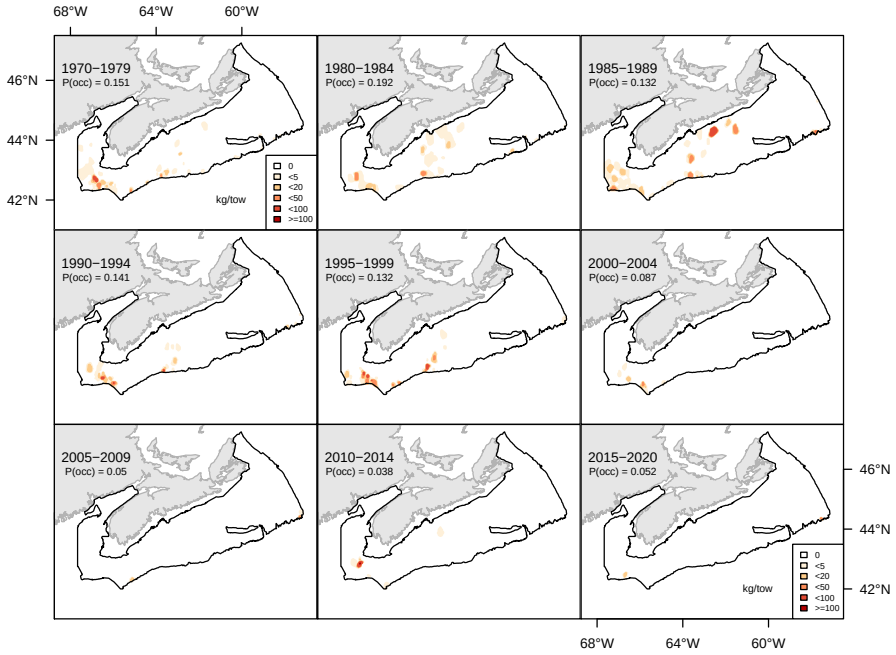


Figure 7.37A. Inverse distance weighted distribution of catch biomass (kg/tow) for Greater argentine.

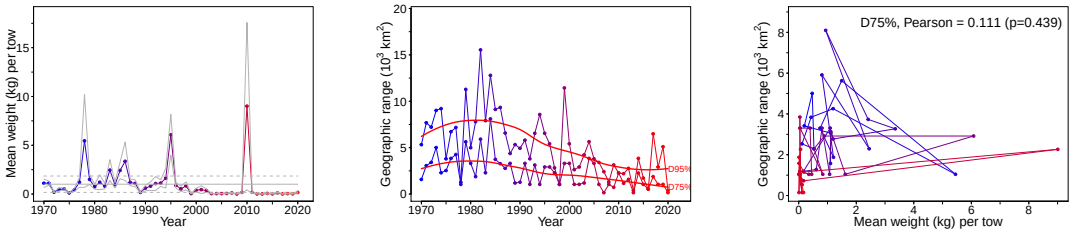


Figure 7.37B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Greater argentine.

7.38 Arctic hookear sculpin (Hameçon neigeux) - species code 306 (category LI)

Scientific name: Artediellus uncinatus

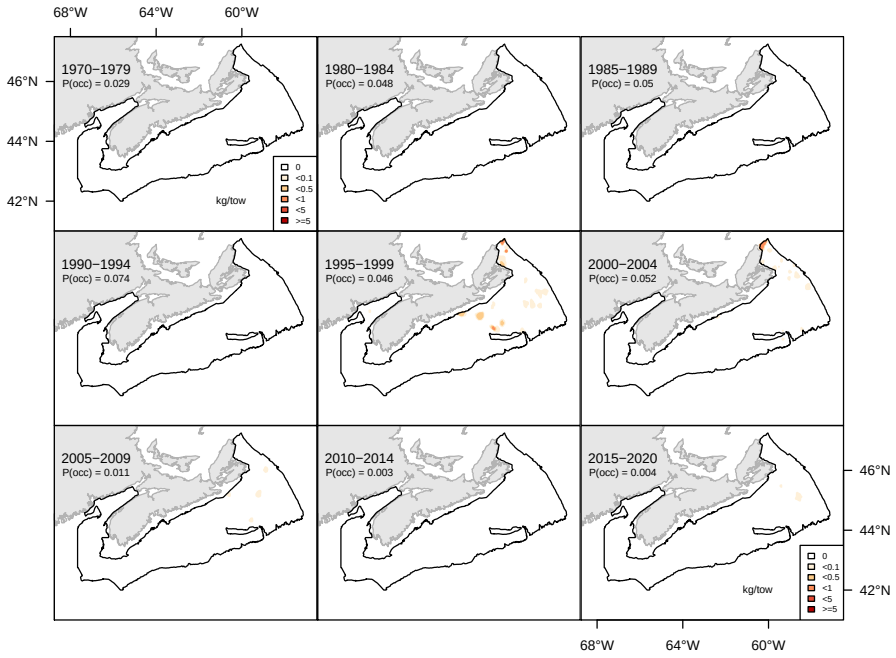


Figure 7.38A. Inverse distance weighted distribution of catch biomass (kg/tow) for Arctic hookear sculpin.

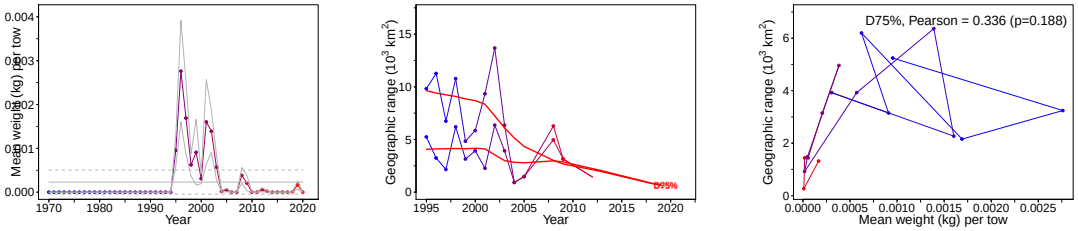


Figure 7.38B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Arctic hookear sculpin.

7.39 Atlantic poacher (Agone atlantique) - species code 350 (category LI)

Scientific name: Leptagonus decagonus

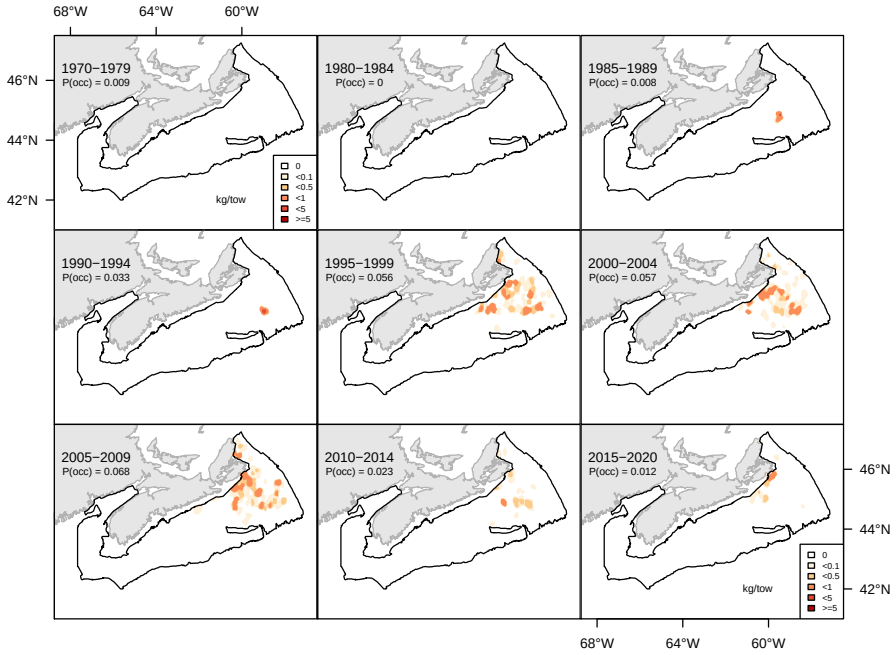


Figure 7.39A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic poacher.

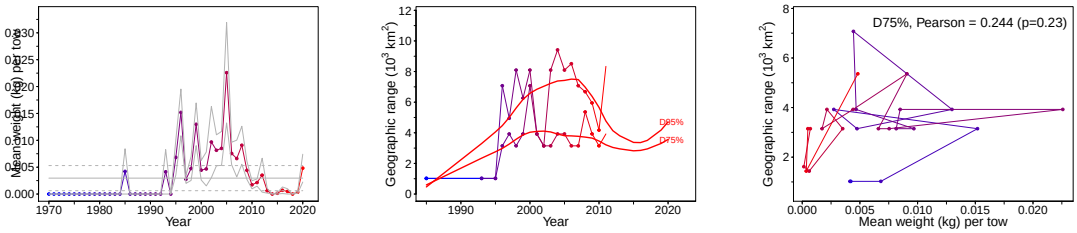


Figure 7.39B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic poacher.

7.40 Marlin-spike grenadier (Grenadier du Grand Banc) - species code 410 (category LI)

Scientific name: Nezumia bairdii

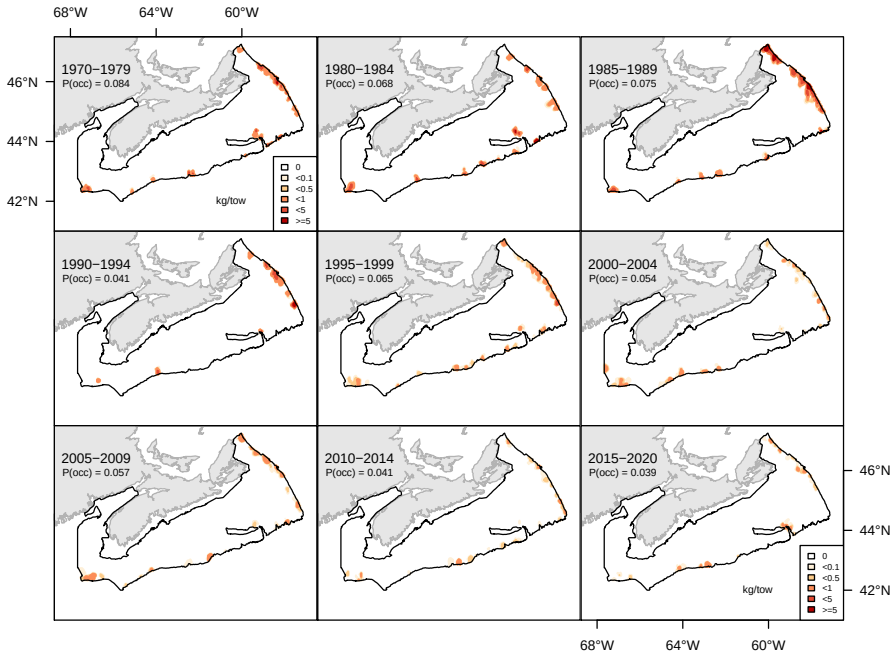


Figure 7.40A. Inverse distance weighted distribution of catch biomass (kg/tow) for Marlin-spike grenadier.

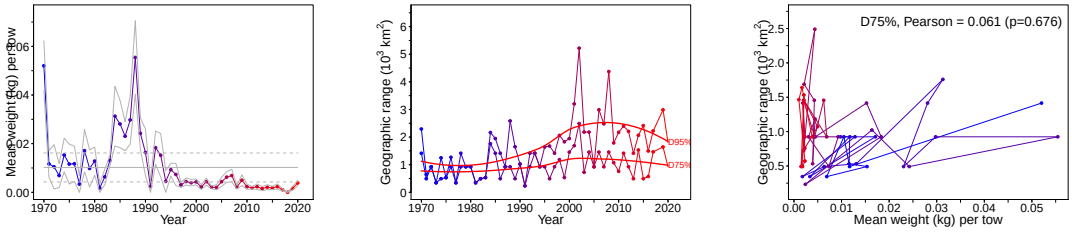


Figure 7.40B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Marlin-spike grenadier.

7.41 Lumpfish (Lompe) - species code 501 (category LI)

Scientific name: Cyclopterus lumpus

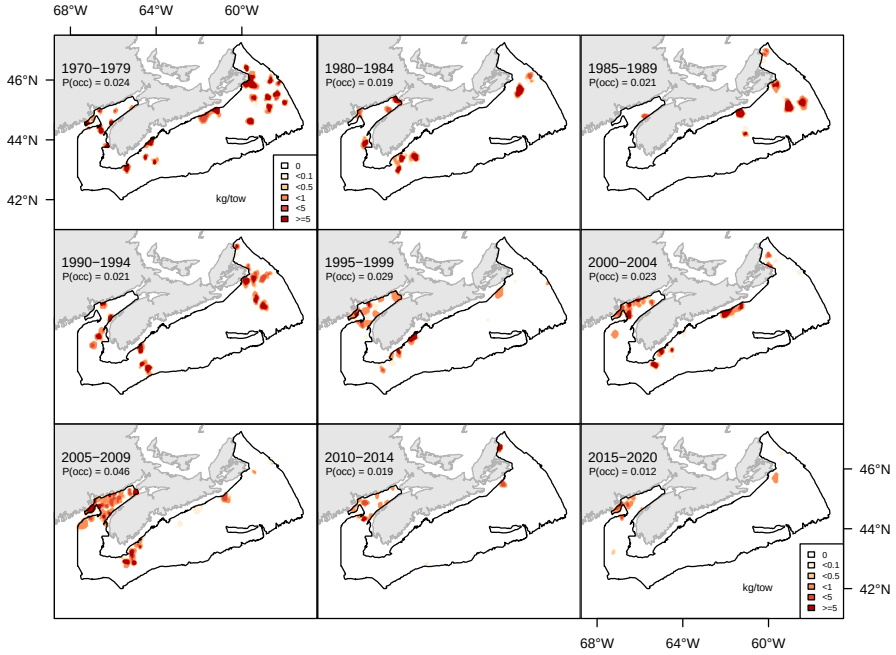


Figure 7.41A. Inverse distance weighted distribution of catch biomass (kg/tow) for Lumpfish.

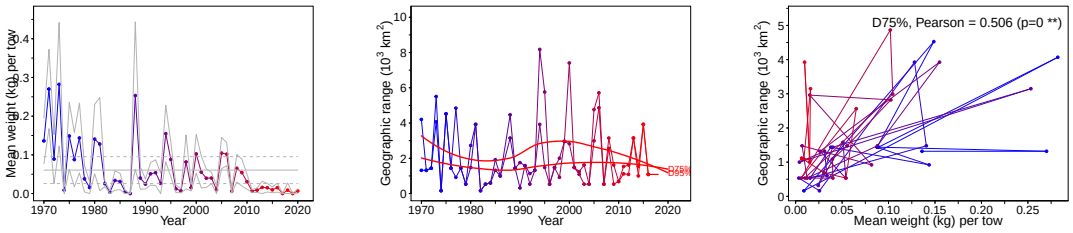


Figure 7.41B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Lumpfish.

7.42 Atlantic spiny lumpsucker (Petite poule de mer atlantique) - species code 502 (category LI)

Scientific name: Eumicrotremus spinosus

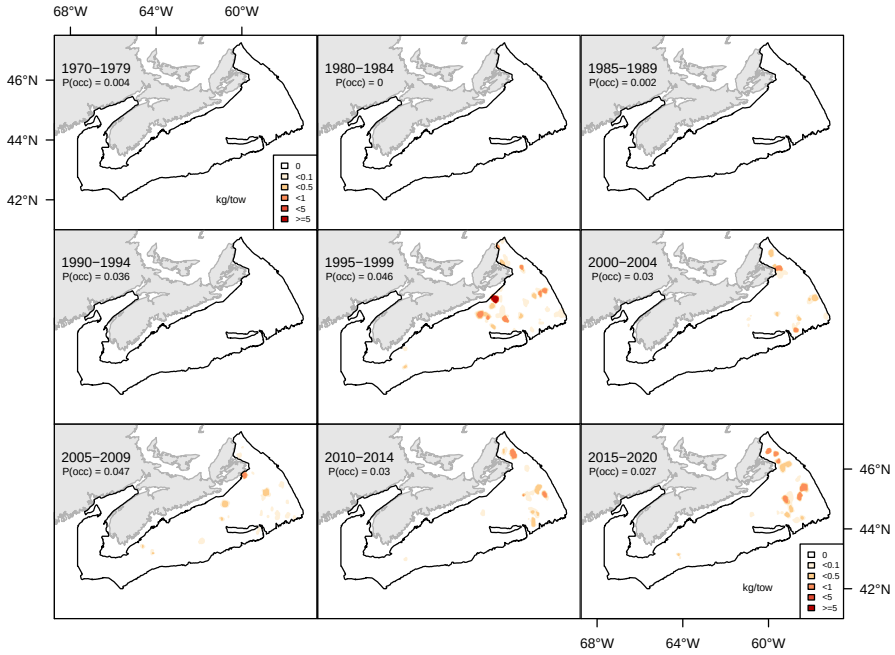


Figure 7.42A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic spiny lumpsucker.

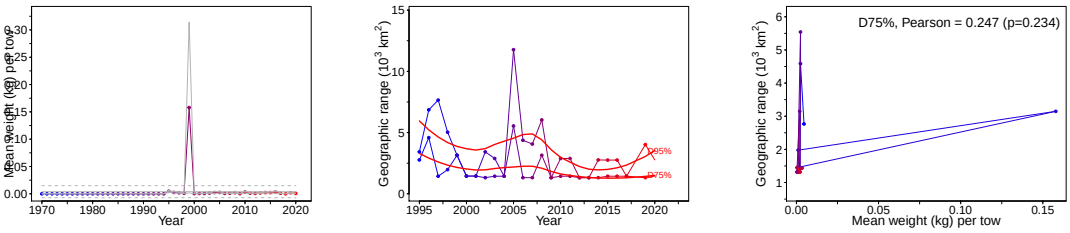


Figure 7.42B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic spiny lumpsucker.

7.43 Sand lance (Lançon) - species code 610 (category LI)

Scientific name: Ammodytes dubius

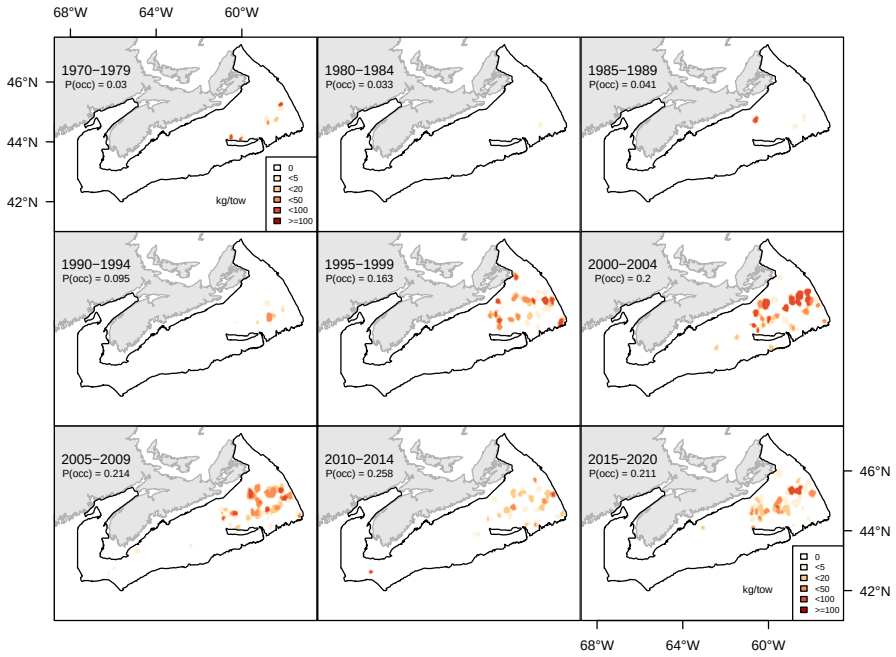


Figure 7.43A. Inverse distance weighted distribution of catch biomass (kg/tow) for Sand lance.

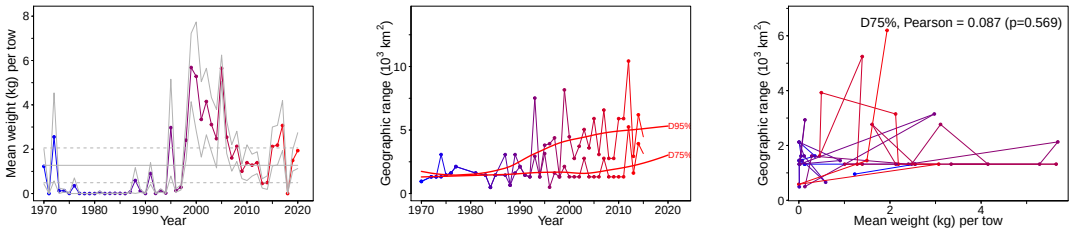


Figure 7.43B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Sand lance.

7.44 Snakeblenny (Lompénie-serpent) - species code 622 (category LI)

Scientific name: Lumpenus lampretaeformis

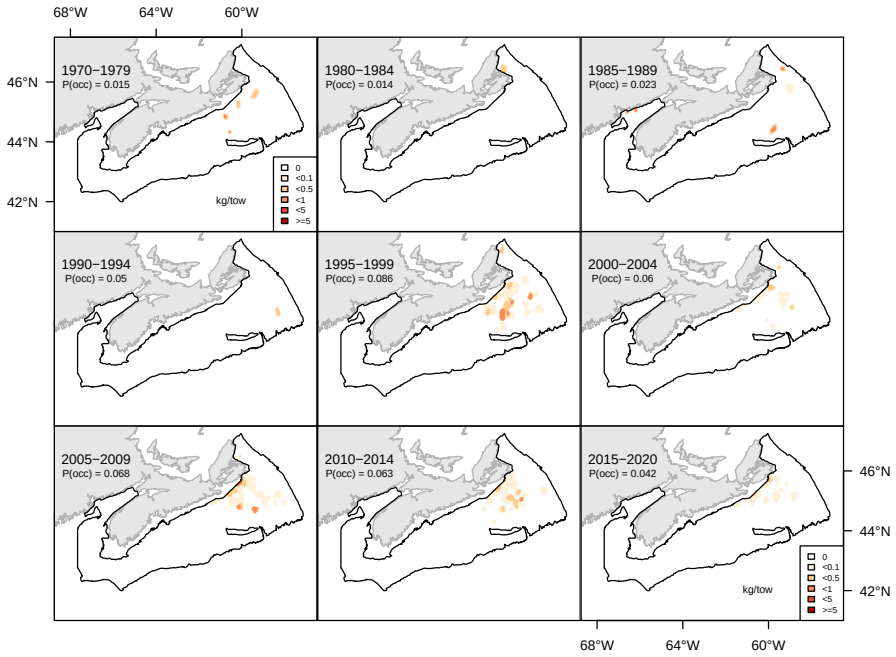


Figure 7.44A. Inverse distance weighted distribution of catch biomass (kg/tow) for Snakeblenny.

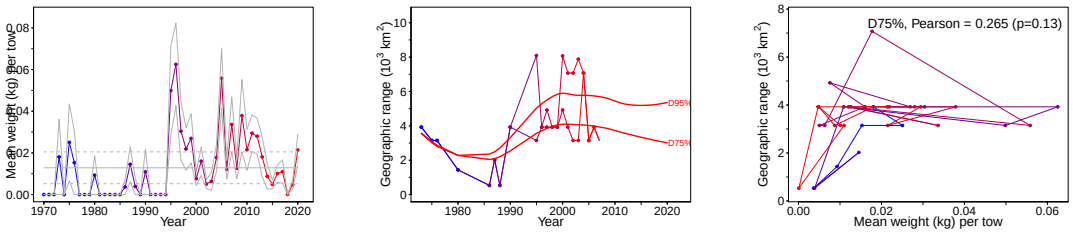


Figure 7.44B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Snakeblenny.

7.45 Daubed shanny (Lompénie tachetée) - species code 623 (category LI)

Scientific name: Leptoclinus maculatus

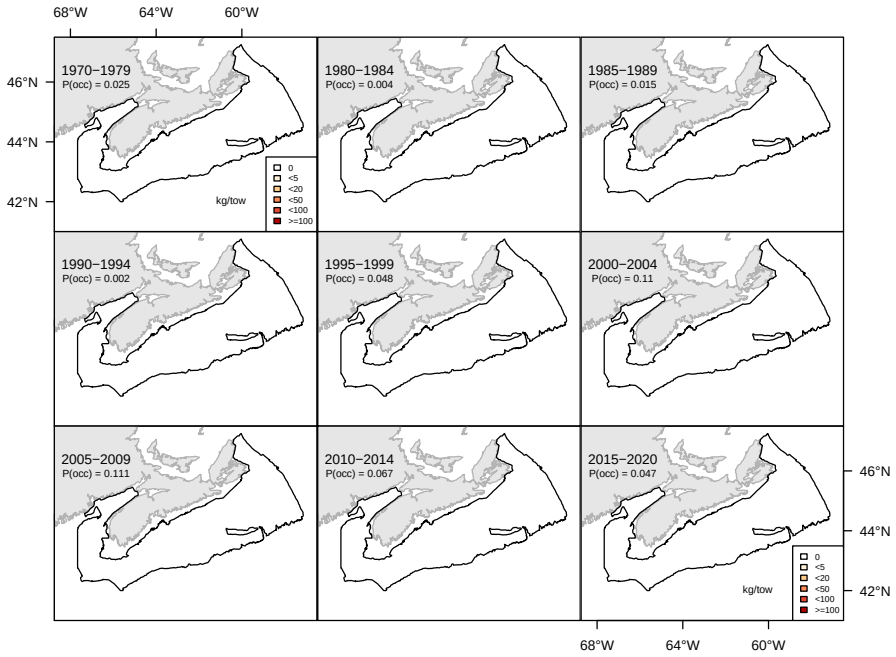


Figure 7.45A. Inverse distance weighted distribution of catch biomass (kg/tow) for Daubed shanny.

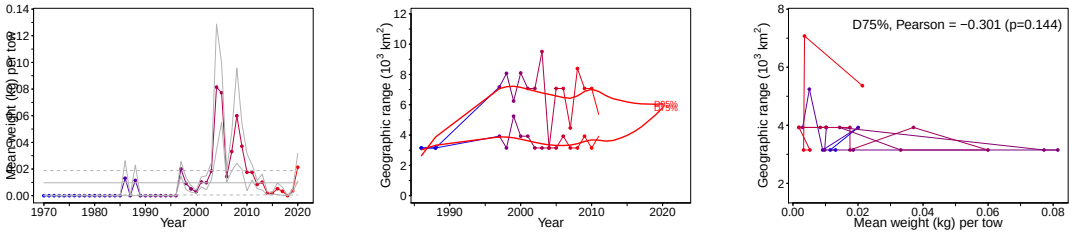


Figure 7.45B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Daubed shanny.

7.46 Vahl's eelpout (Lycode à carreaux) - species code 647 (category LI)

Scientific name: Lycodes vahlii

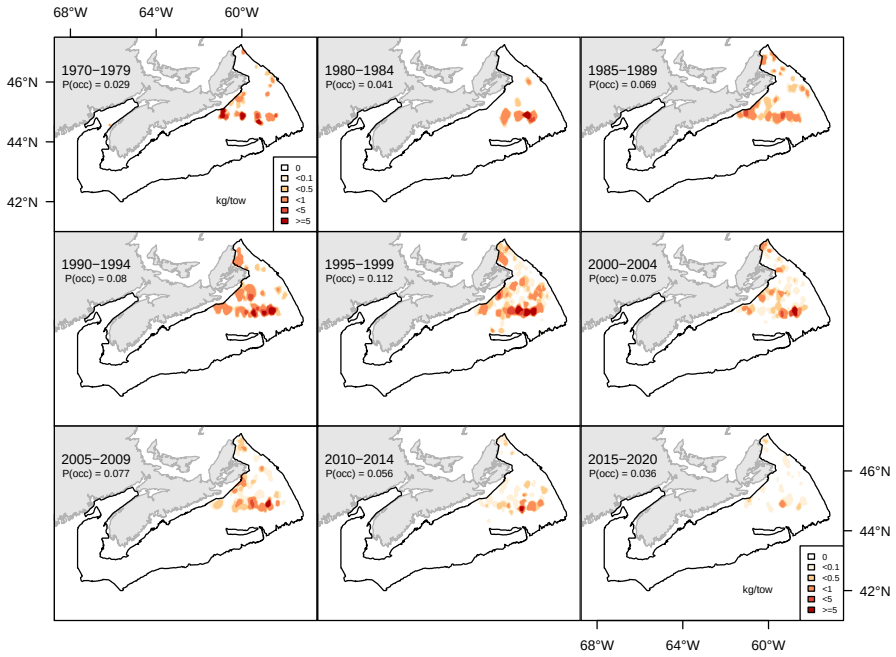


Figure 7.46A. Inverse distance weighted distribution of catch biomass (kg/tow) for Vahl's eelpout.

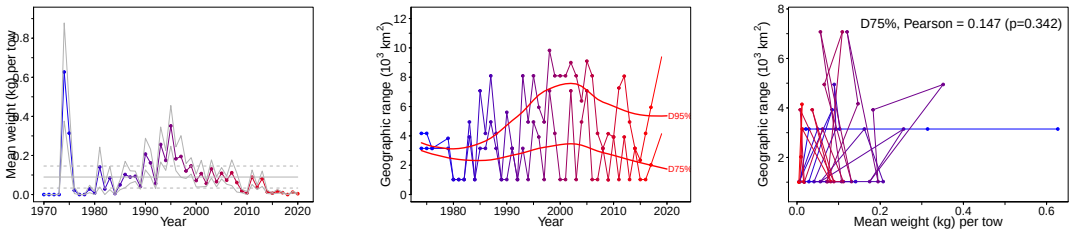


Figure 7.46B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Vahl's eelpout.

7.47 Atlantic butterfish (Stromaté fossette) - species code 701 (category LI)

Scientific name: Peprilus triacanthus

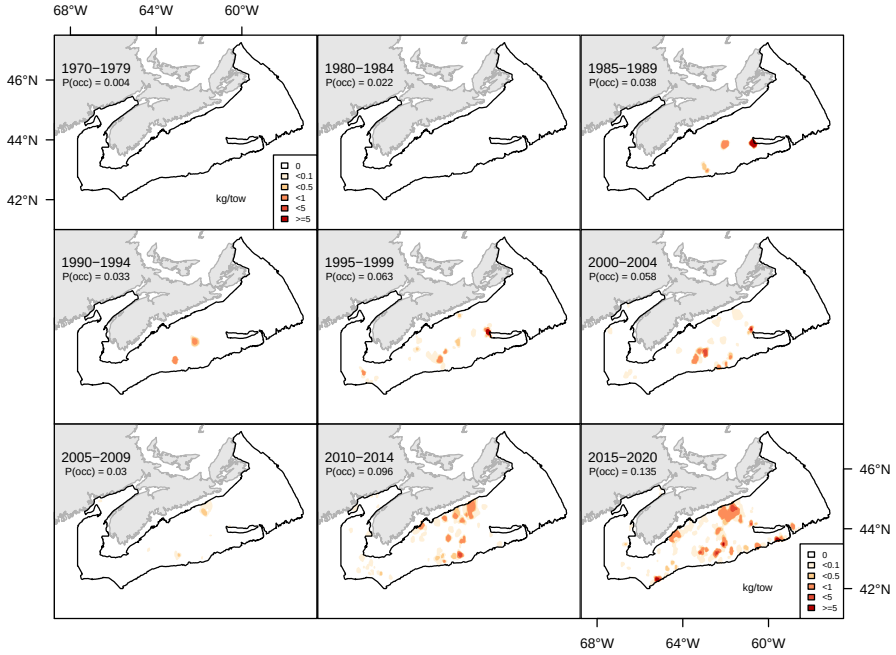


Figure 7.47A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic butterfish.

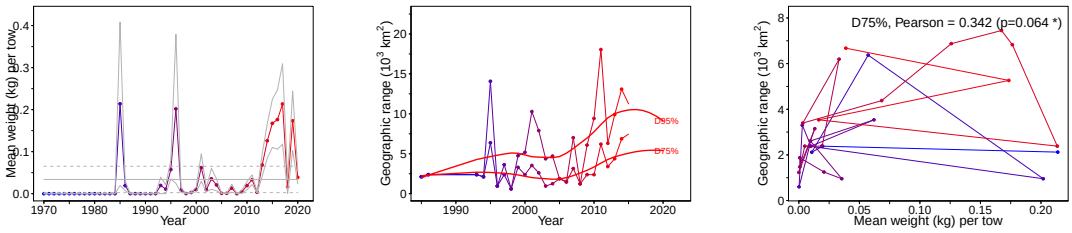


Figure 7.47B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic butterfish.

7.48 Atlantic hookear sculpin (Hameçon atlantique) - species code 880 (category LI)

Scientific name: Artediellus atlanticus

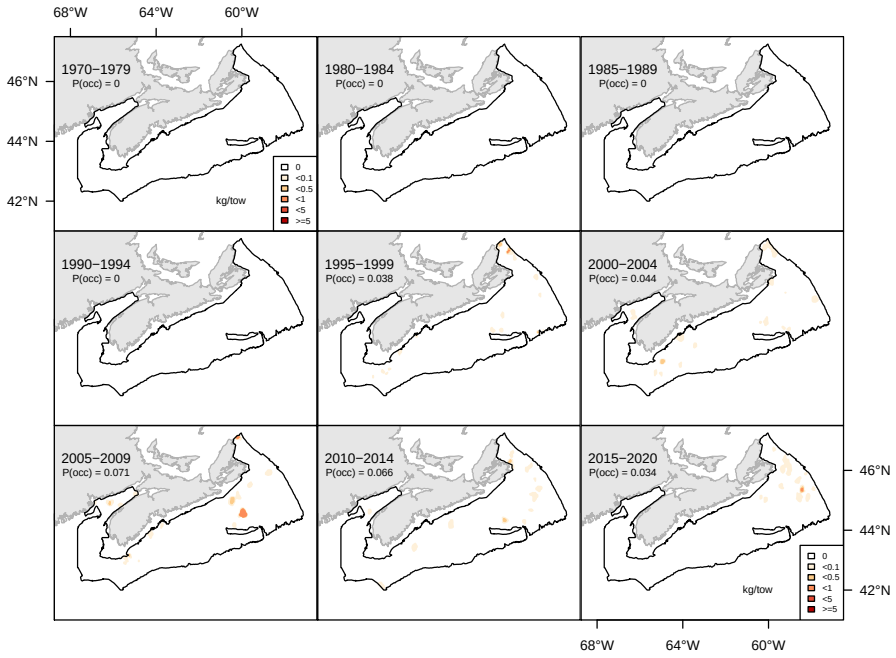


Figure 7.48A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic hookear sculpin.

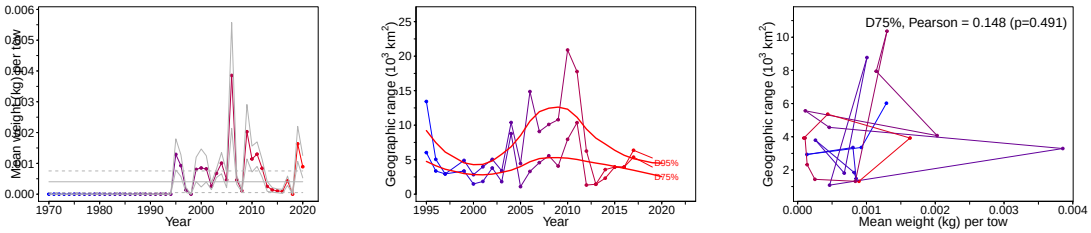


Figure 7.48B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic hookear sculpin.

7.49 Barndoor skate (Grande raie) - species code 200 (category LI)

Scientific name: Dipturus laevis

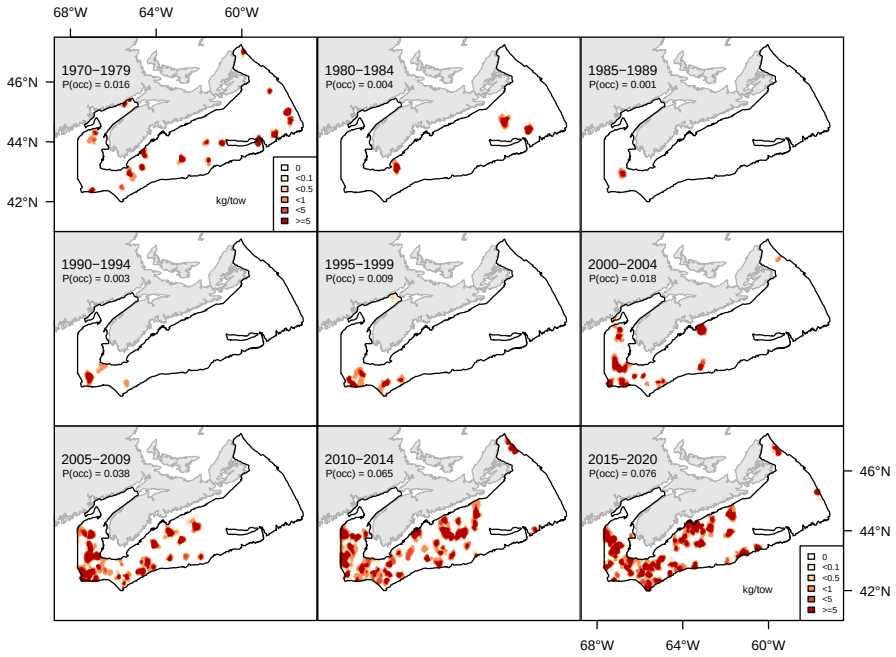


Figure 7.49A. Inverse distance weighted distribution of catch biomass (kg/tow) for Barndoor skate.

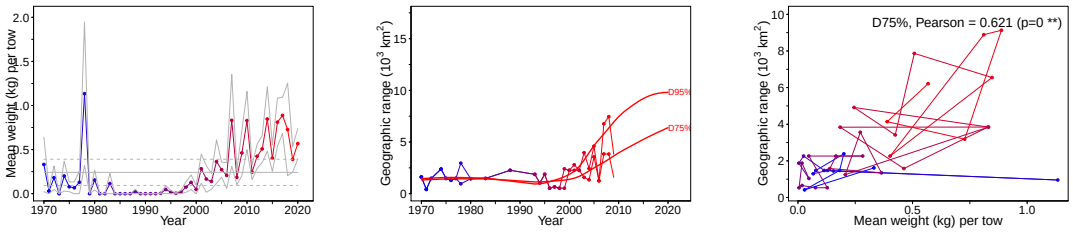


Figure 7.49B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Barndoor skate.

7.50 Little skate (Raie hérisson) - species code 203 (category LI)

Scientific name: Leucoraja erinacea

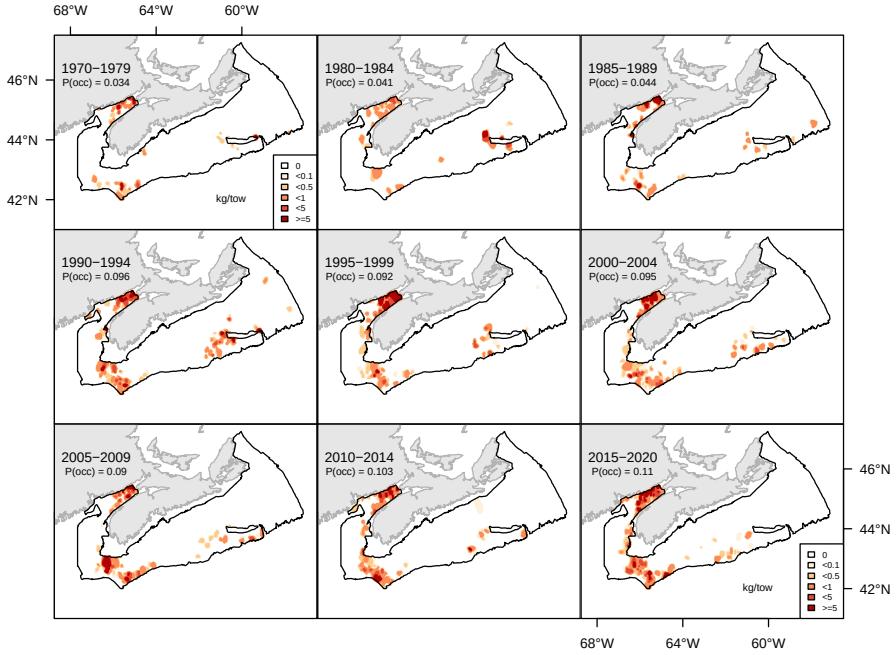


Figure 7.50A. Inverse distance weighted distribution of catch biomass (kg/tow) for Little skate.

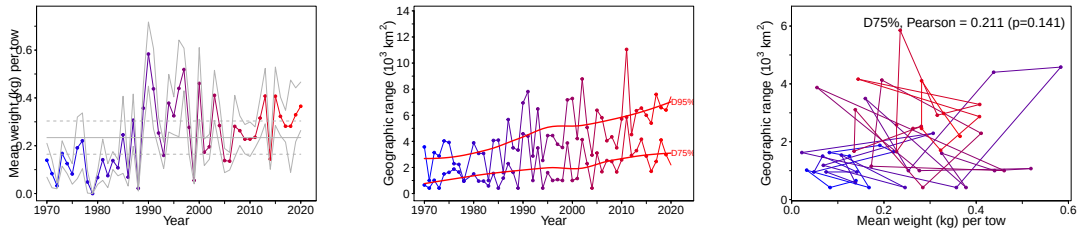


Figure 7.50B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Little skate.

7.51 Northern prawn (Crevette nordique) - species code 2211 (category SF)

Scientific name: Pandalus borealis

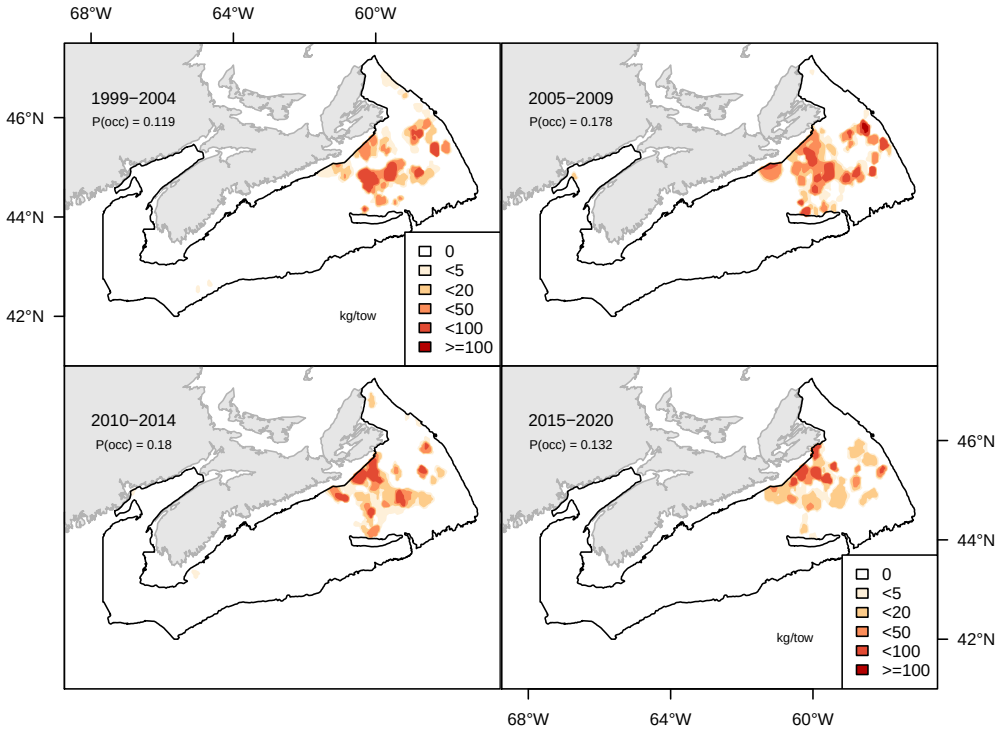


Figure 7.51A. Inverse distance weighted distribution of catch biomass (kg/tow) for Northern prawn.

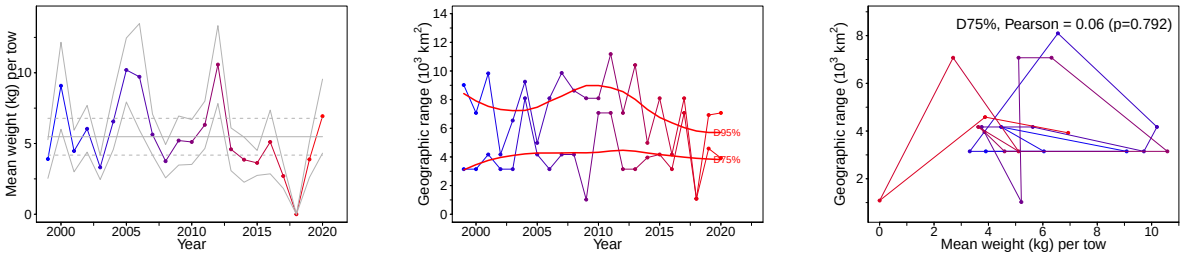


Figure 7.51B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Northern prawn.

7.52 Jonah crab (Tourteau jona) - species code 2511 (category SF)

Scientific name: Cancer borealis

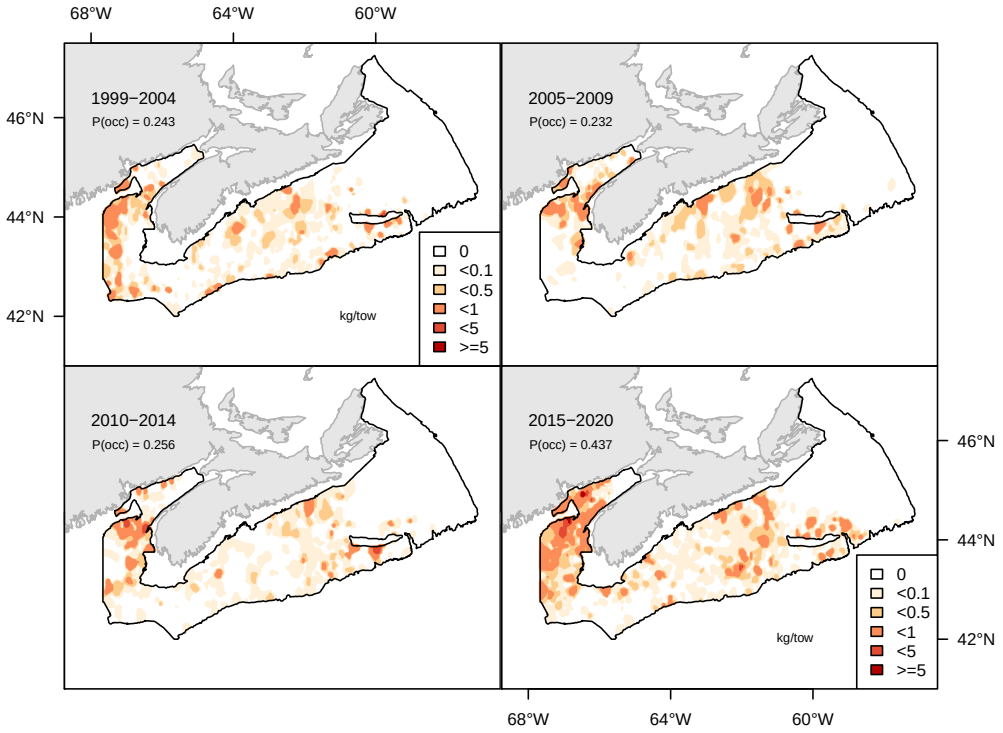


Figure 7.52A. Inverse distance weighted distribution of catch biomass (kg/tow) for Jonah crab.

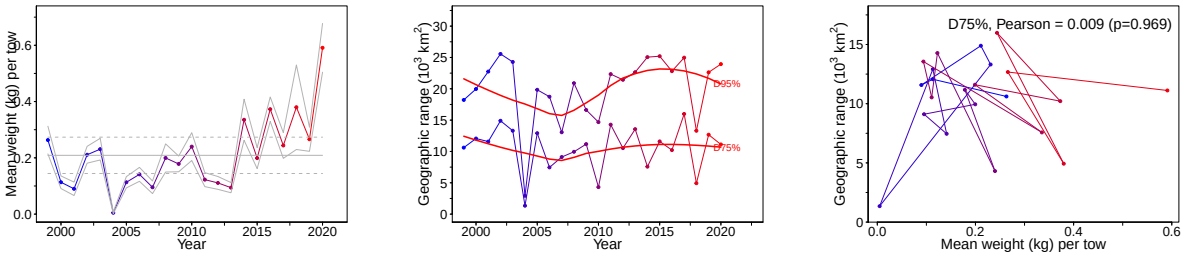


Figure 7.52B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Jonah crab.

7.53 Atlantic rock crab (Tourteau poïnclos) - species code 2513 (category SF)

Scientific name: Cancer irroratus

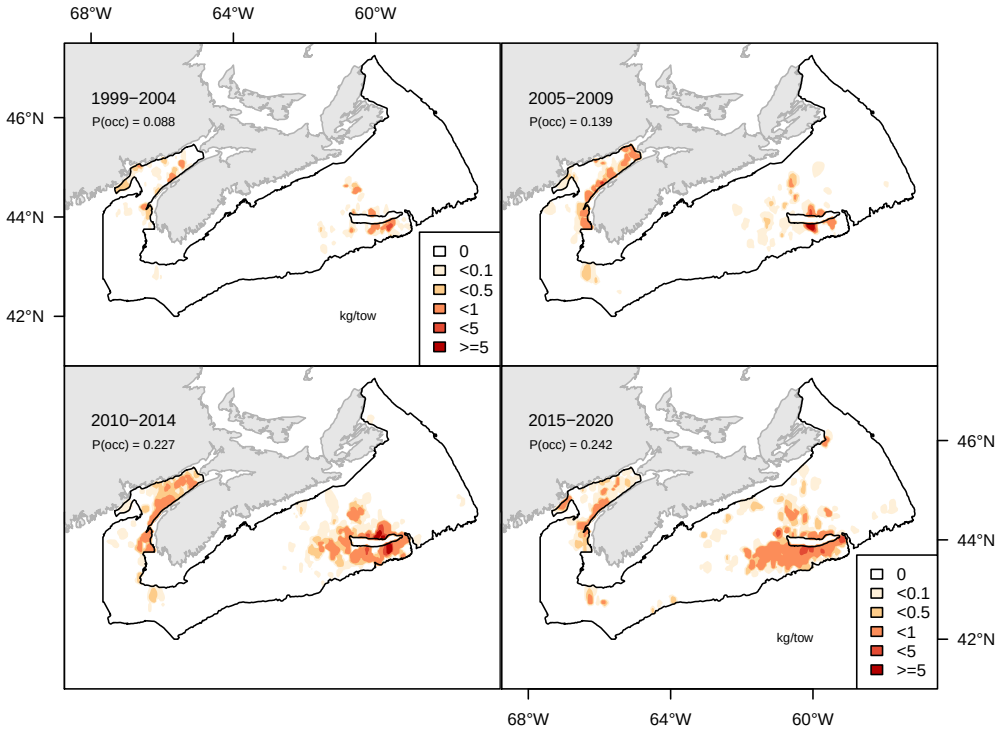


Figure 7.53A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic rock crab.

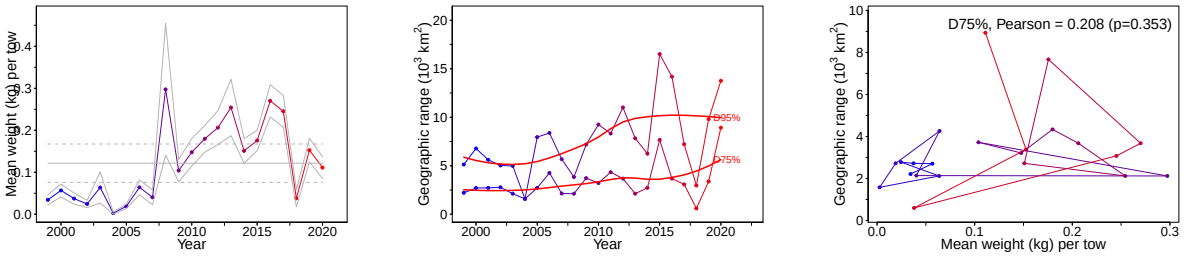


Figure 7.53B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic rock crab.

7.54 Arctic lyre crab (Crabe Hyas coarctatus) - species code 2521 (category SF)

Scientific name: Hyas coarctatus

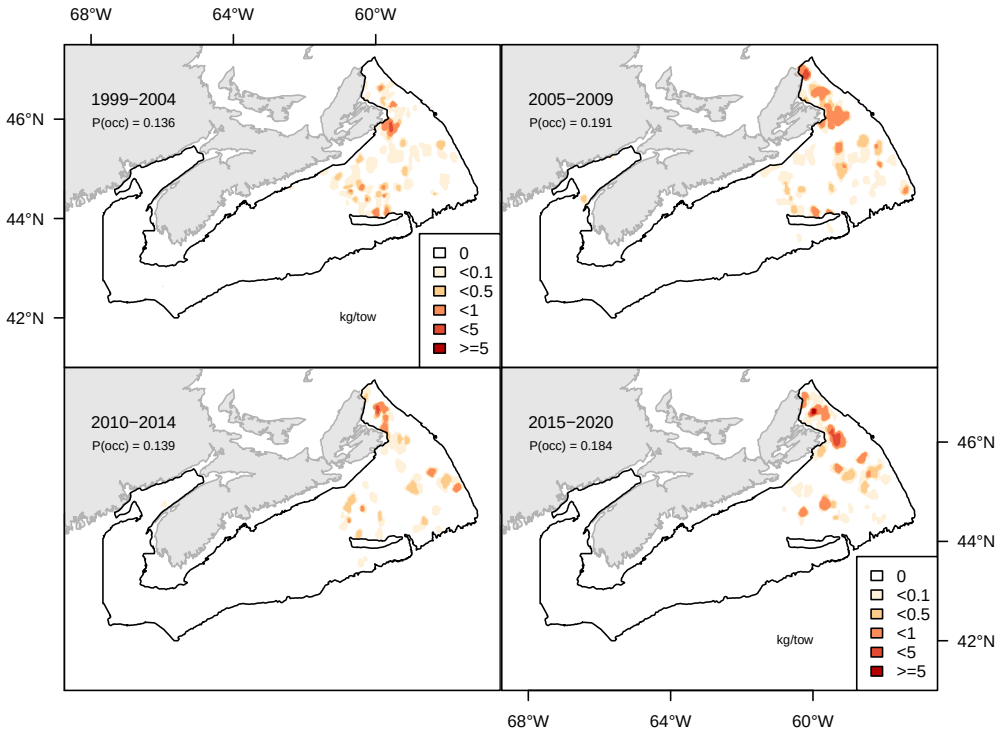


Figure 7.54A. Inverse distance weighted distribution of catch biomass (kg/tow) for Arctic lyre crab.

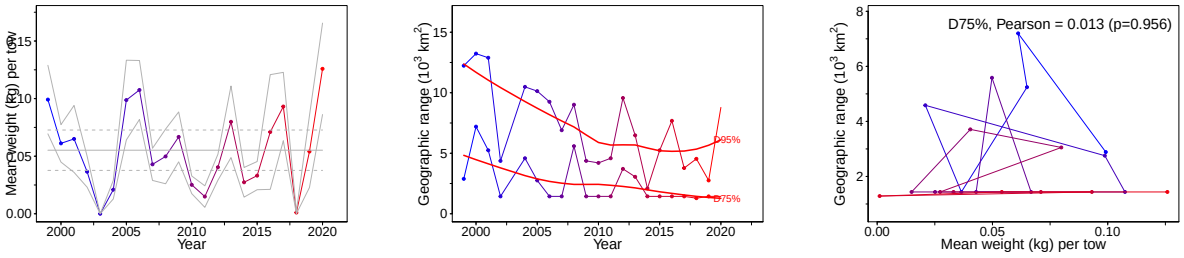


Figure 7.54B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Arctic lyre crab.

7.55 Atlantic king crab (Crabe épineux du nord) - species code 2523 (category SF)

Scientific name: Lithodes maja

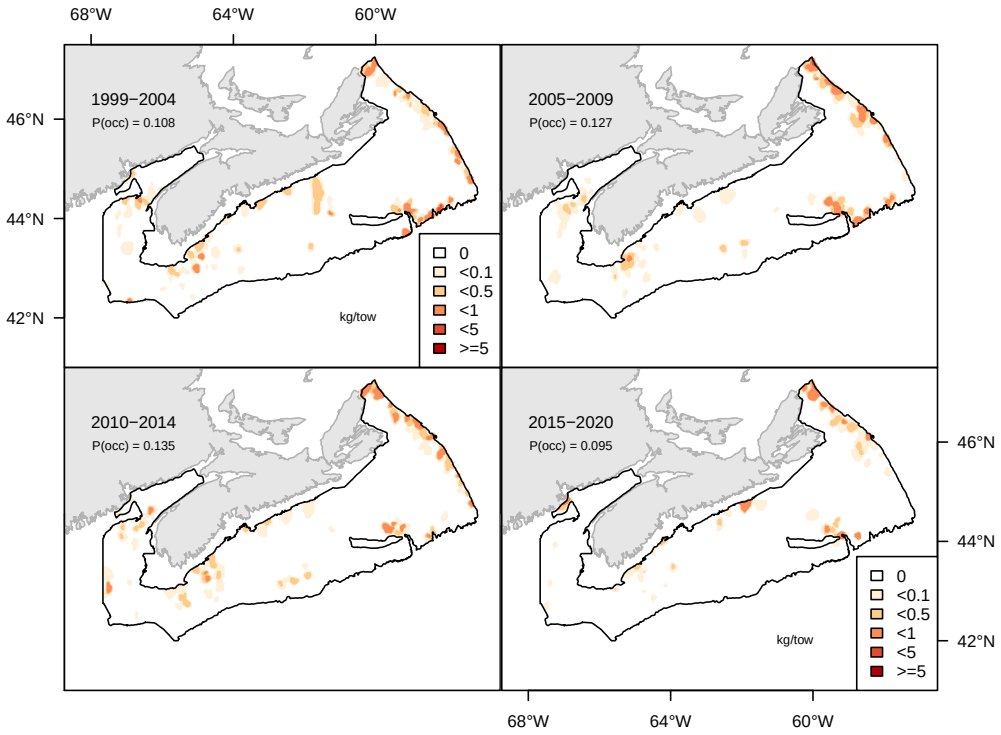


Figure 7.55A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic king crab.

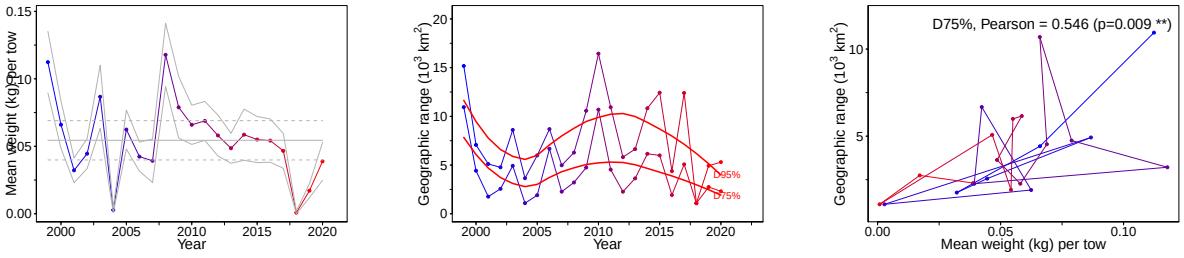


Figure 7.55B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic king crab.

7.56 Queen crab (Crabe des neiges) - species code 2526 (category SF)

Scientific name: Chionoecetes opilio

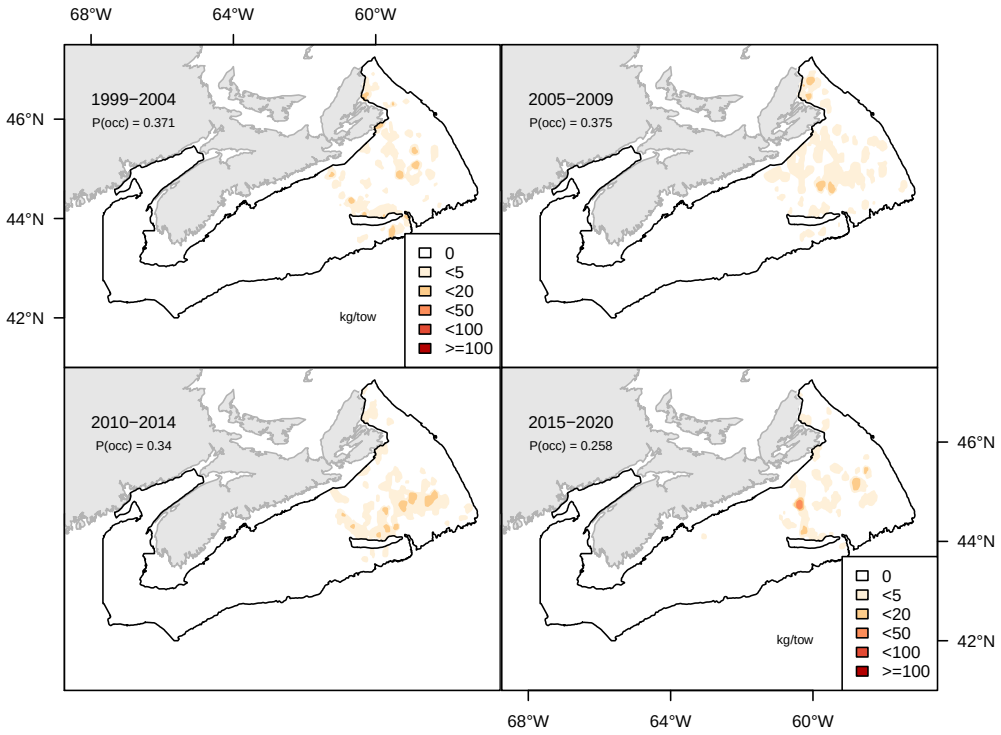


Figure 7.56A. Inverse distance weighted distribution of catch biomass (kg/tow) for Queen crab.

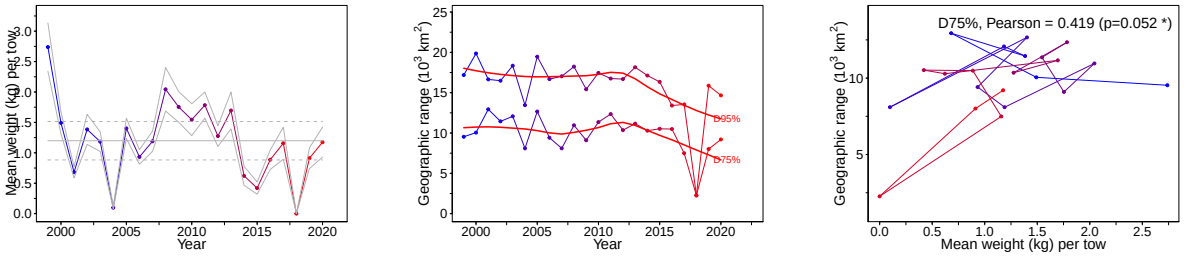


Figure 7.56B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Queen crab.

7.57 Great spider crab (Crabe lyre araignée) - species code 2527 (category SF)

Scientific name: Hyas araneus

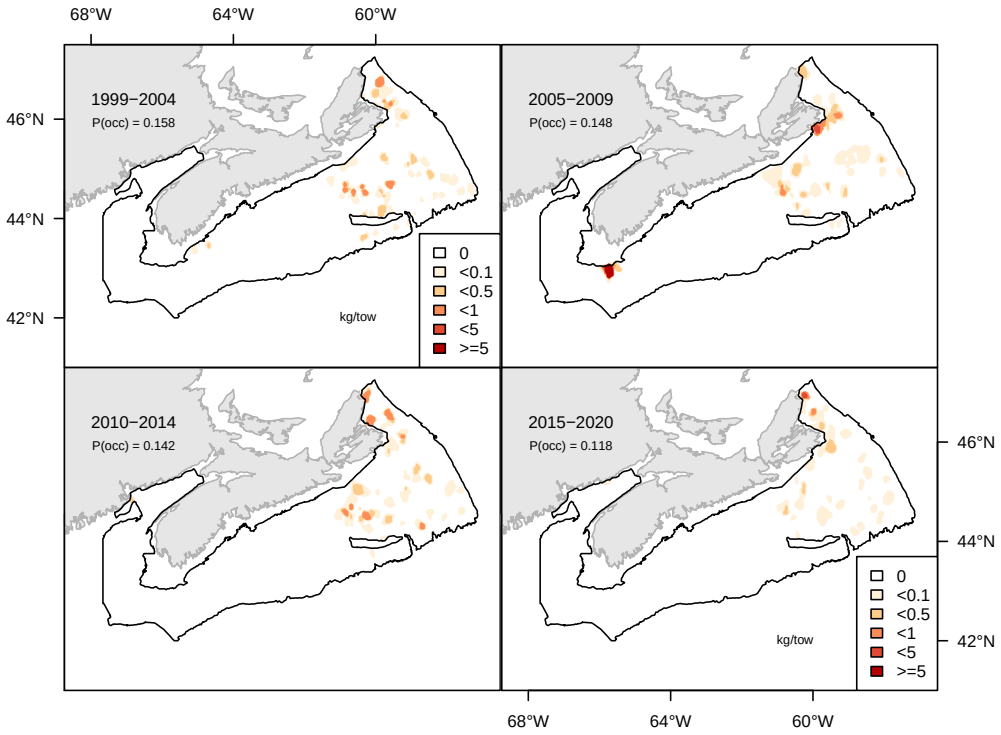


Figure 7.57A. Inverse distance weighted distribution of catch biomass (kg/tow) for Great spider crab.

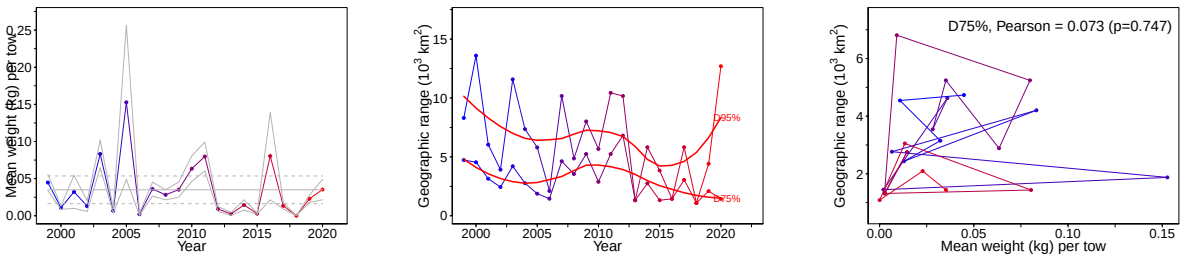


Figure 7.57B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Great spider crab.

7.58 American lobster (Homard américain) - species code 2550 (category SF)

Scientific name: Homarus americanus

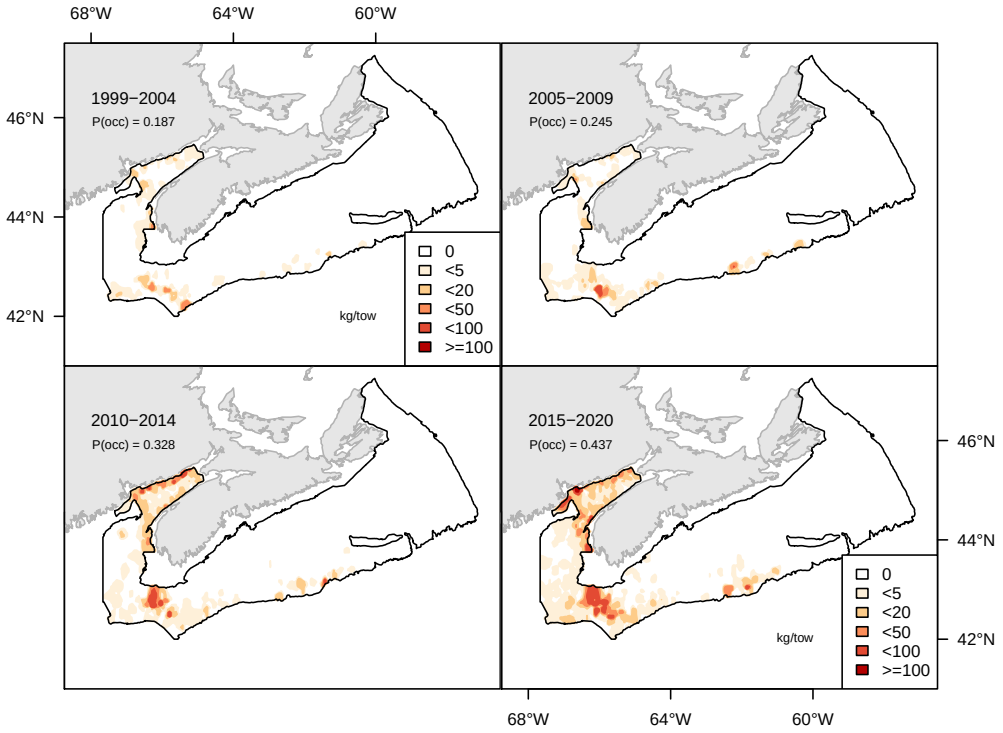


Figure 7.58A. Inverse distance weighted distribution of catch biomass (kg/tow) for American lobster.

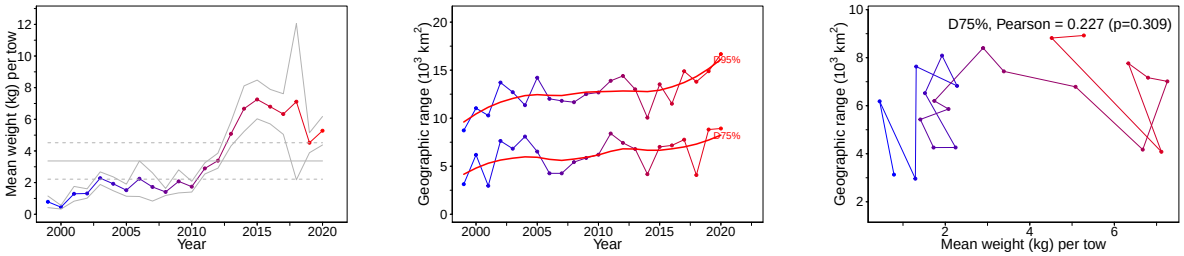


Figure 7.58B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American lobster.

7.59 Sea lamprey (Lamproie marine) - species code 240 (category LR)

Scientific name: Petromyzon marinus

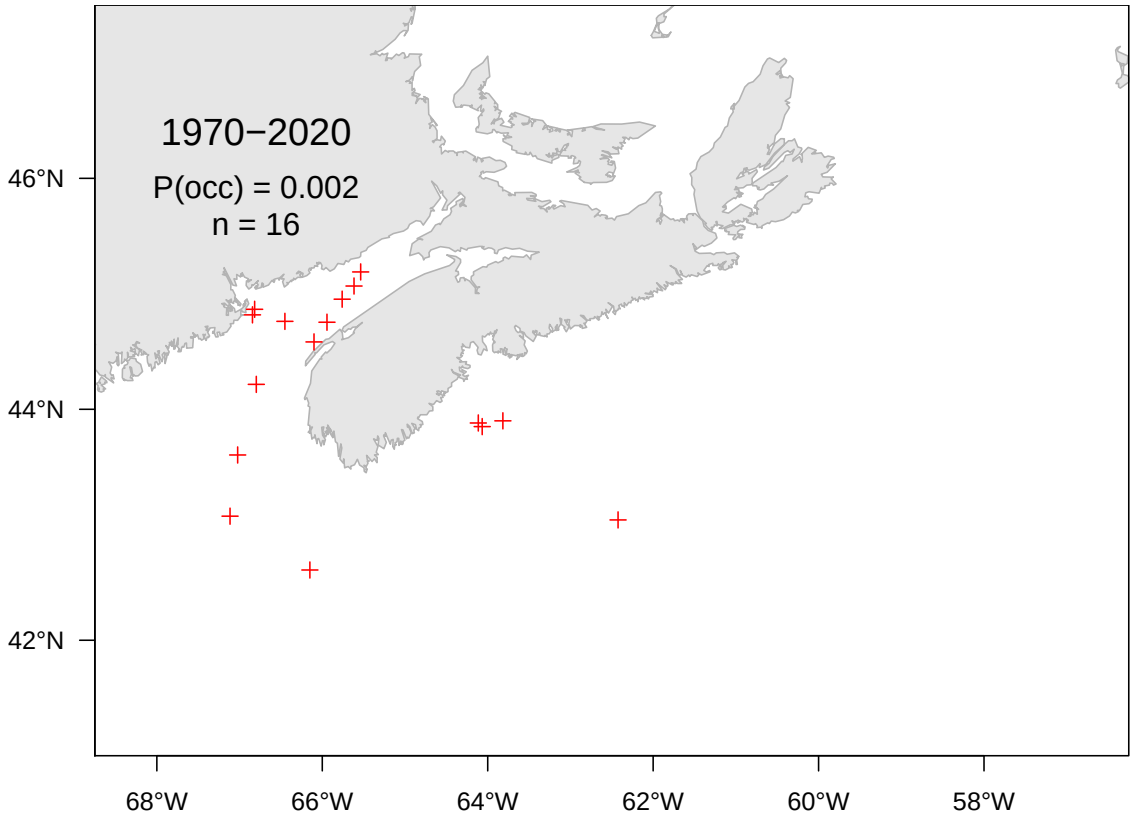


Figure 7.59A. Catch distribution for Sea lamprey.

7.60 Atlantic tomcod (Poulamon atlantique) - species code 17 (category LR)

Scientific name: Microgadus tomcod

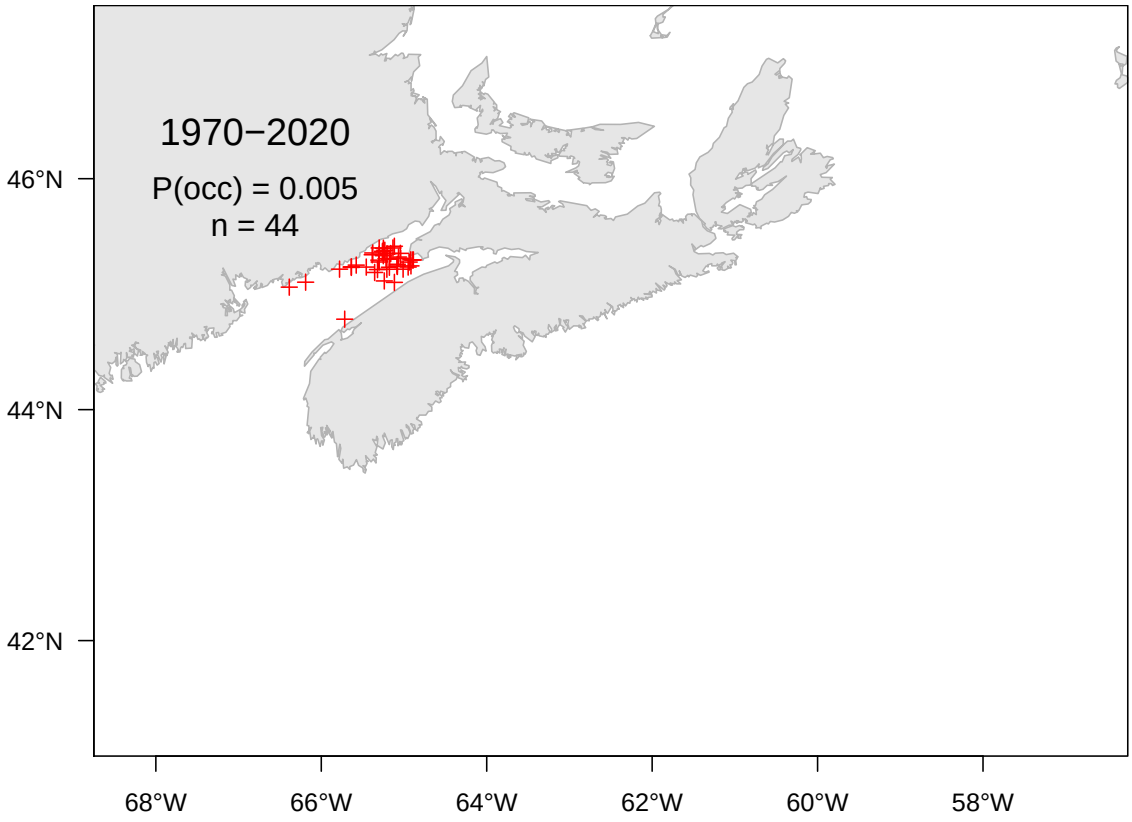


Figure 7.60A. Catch distribution for Atlantic tomcod.

7.61 Offshore silver hake (Merlu argenté du large) - species code 19 (category LR)

Scientific name: Merluccius albidus

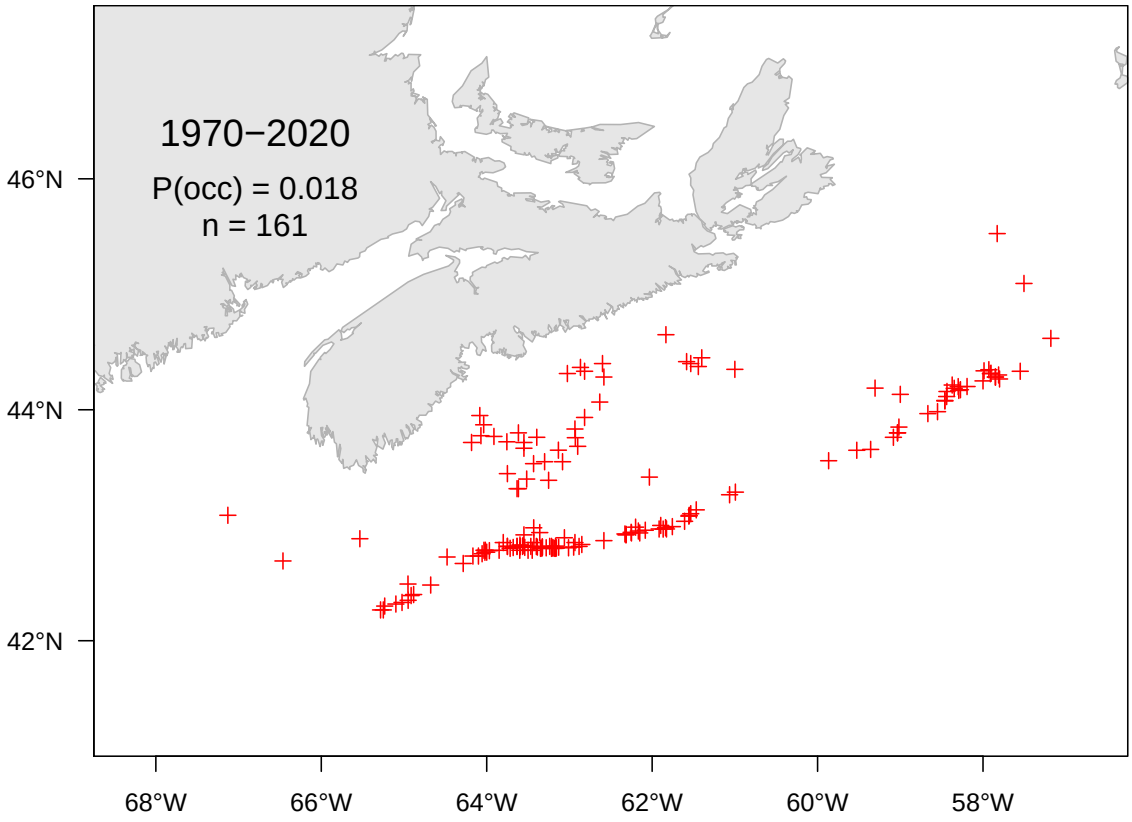


Figure 7.61A. Catch distribution for Offshore silver hake.

7.62 Spotted wolffish (Loup tacheté) - species code 51 (category LR)

Scientific name: Anarhichas minor

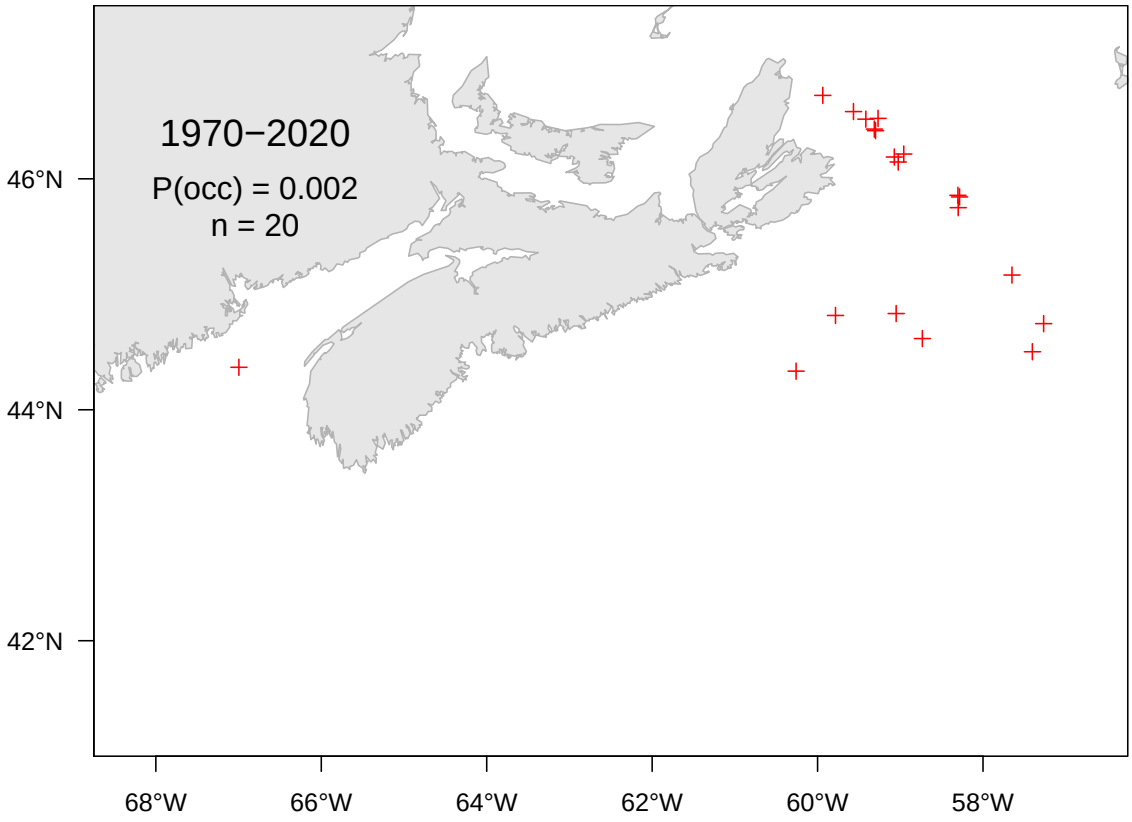


Figure 7.62A. Catch distribution for Spotted wolffish.

7.63 Northern wolffish (Loup à tête large) - species code 52 (category LR)

Scientific name: Anarhichas denticulatus

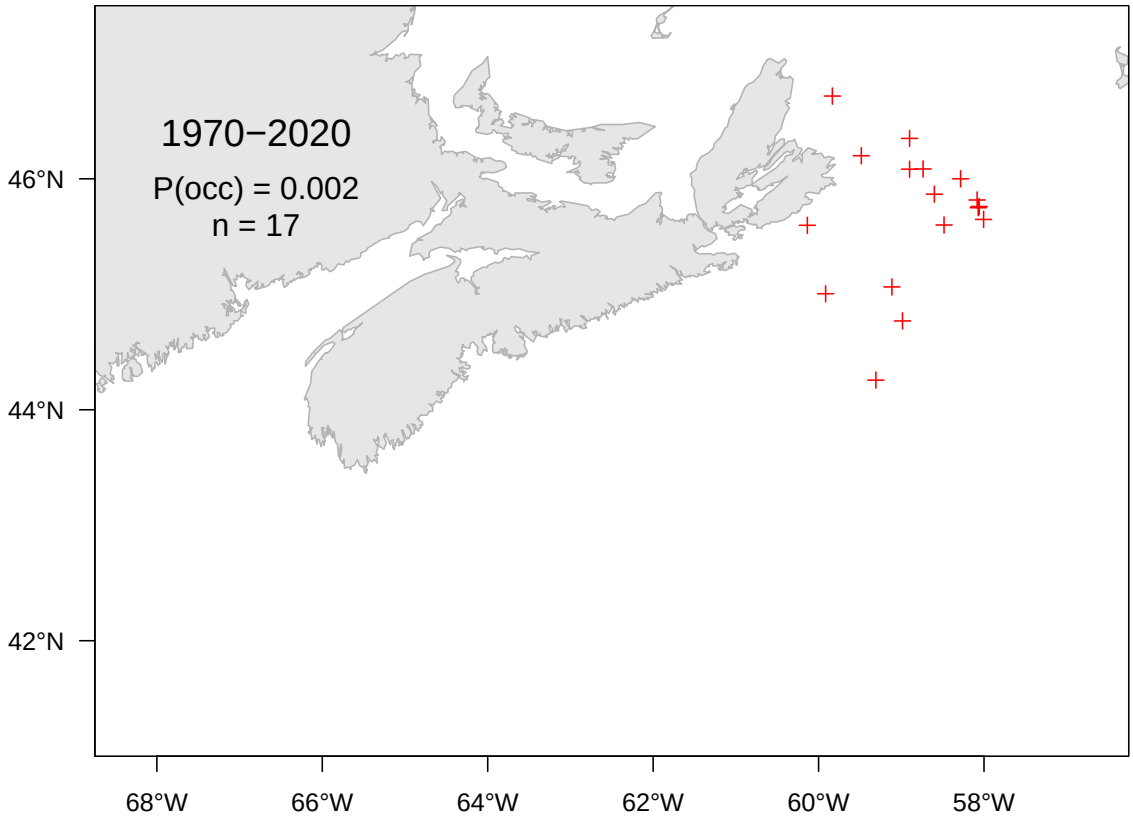


Figure 7.63A. Catch distribution for Northern wolffish.

7.64 Rainbow smelt (Éperlan arc-en-ciel) - species code 63 (category LR)

Scientific name: Osmerus mordax

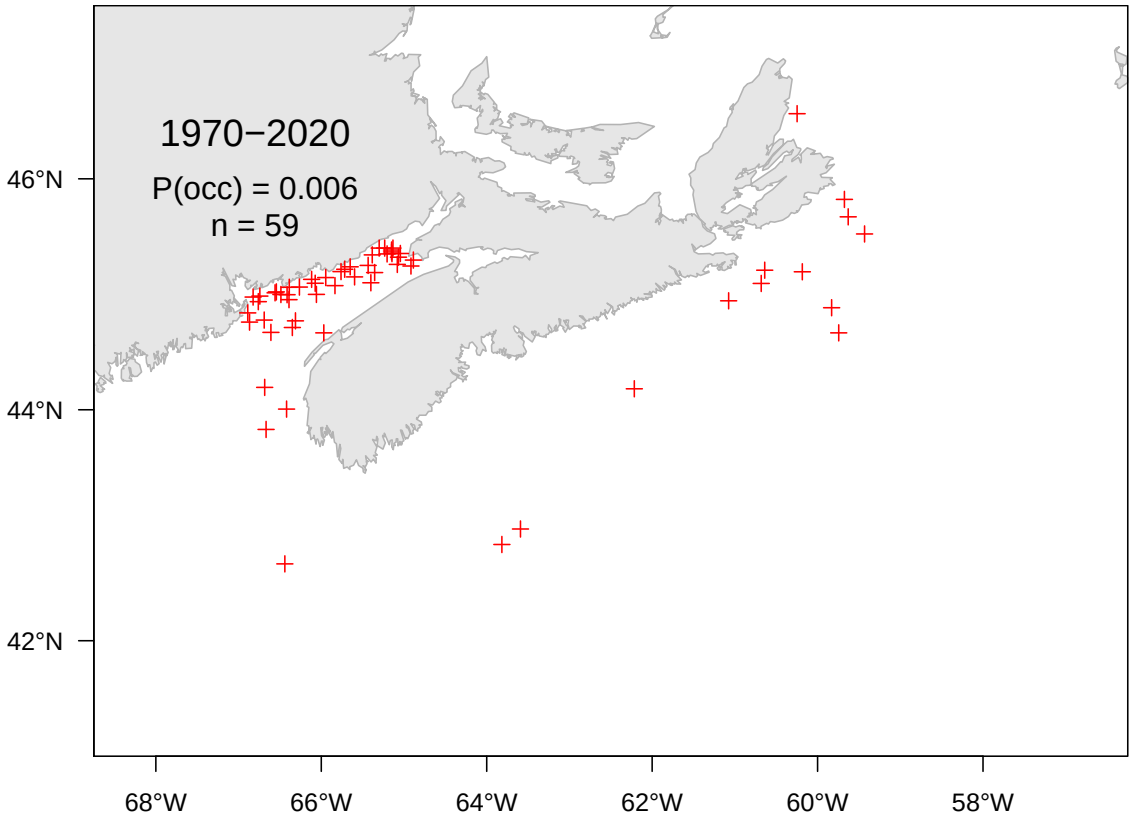


Figure 7.64A. Catch distribution for Rainbow smelt.

7.65 Cunner (Tanche-tautogue) - species code 122 (category LR)

Scientific name: Tautogolabrus adspersus

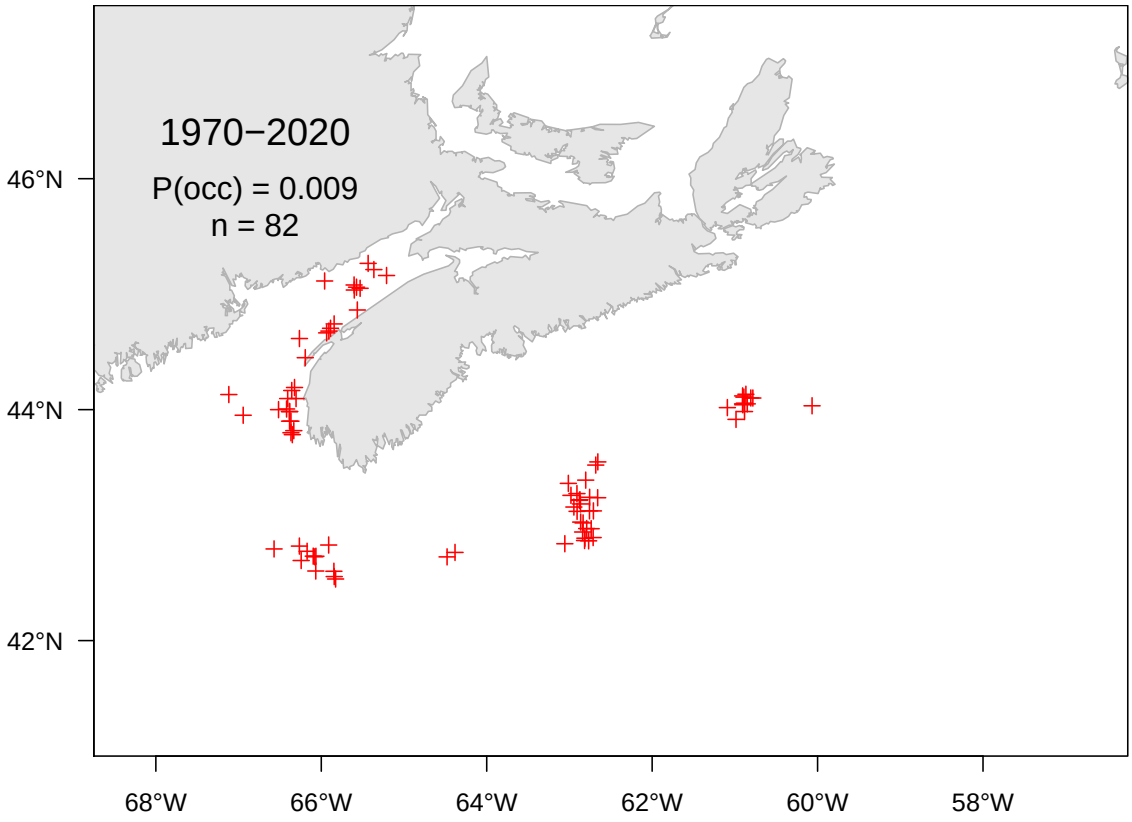


Figure 7.65A. Catch distribution for Cunner.

7.66 Fourspot flounder (Cardeau à quatre ocelles) - species code 142 (category LR)

Scientific name: Hippoglossina oblonga

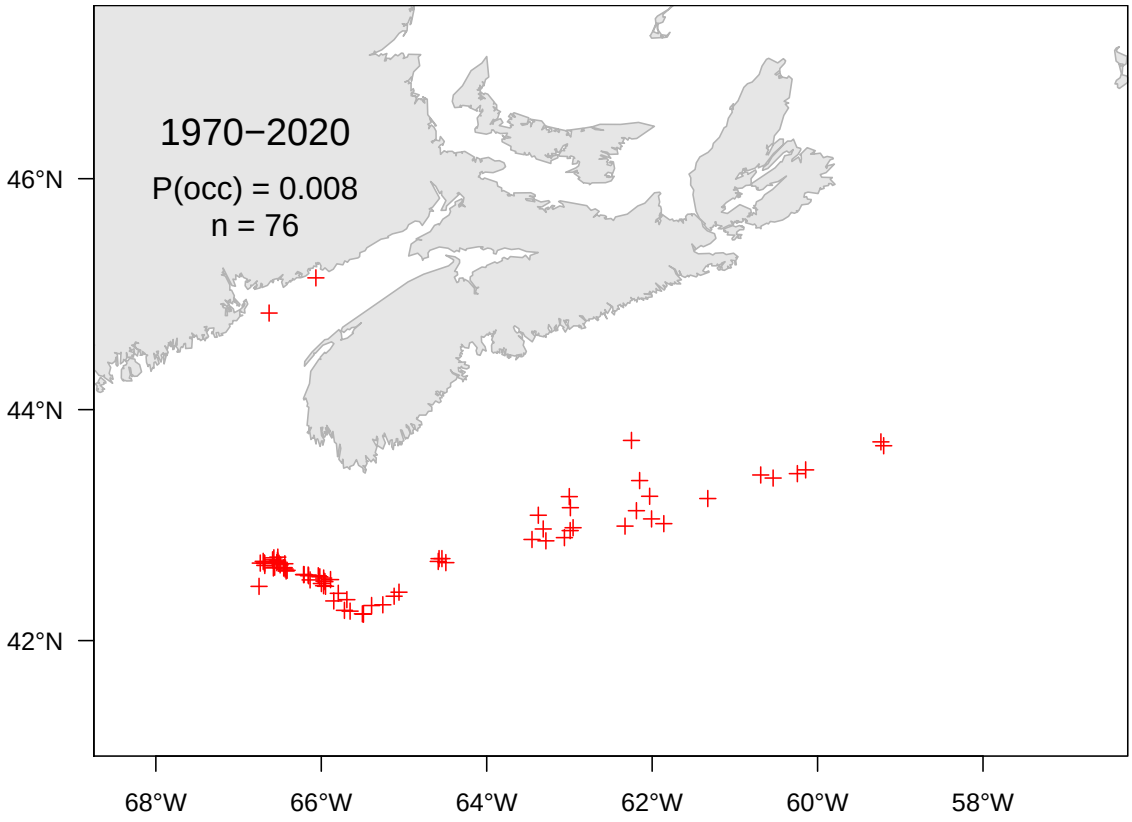


Figure 7.66A. Catch distribution for Fourspot flounder.

7.67 Windowpane flounder (Turbot de sable) - species code 143 (category LR)

Scientific name: Scophthalmus aquosus

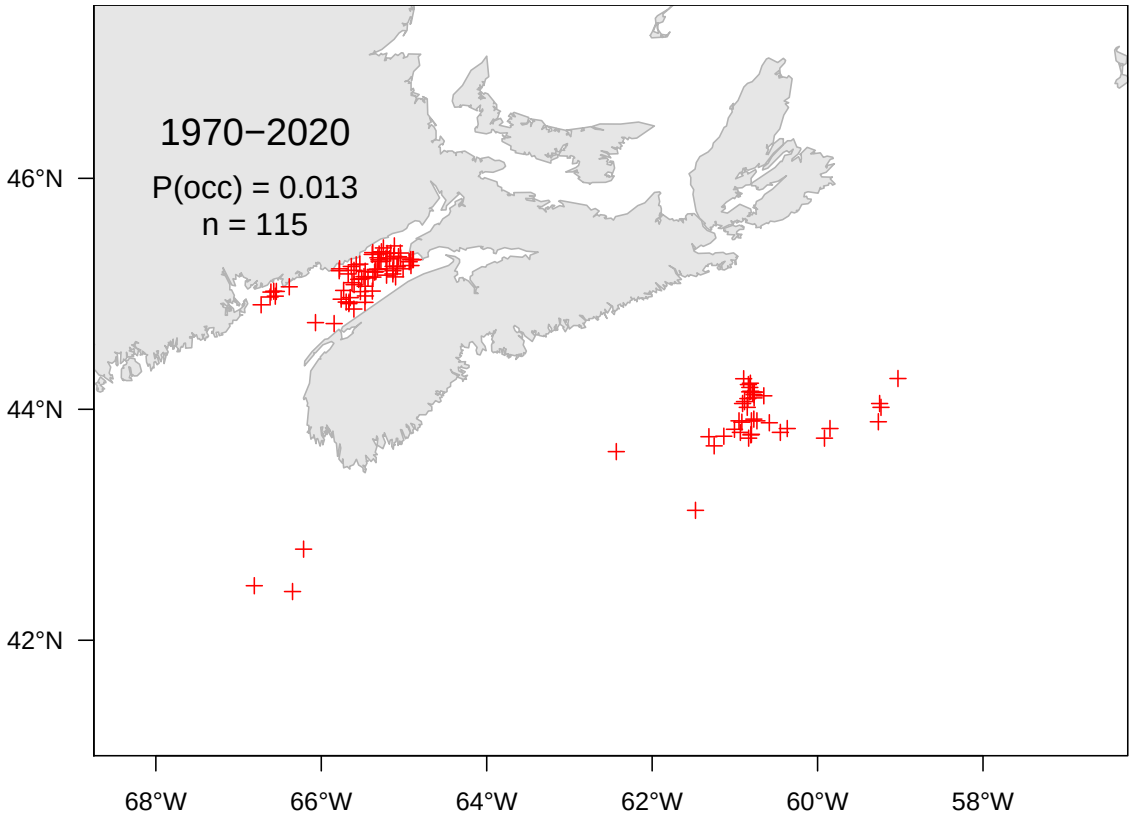


Figure 7.67A. Catch distribution for Windowpane flounder.

7.68 Longnose greeneye (Oeil-vert à long nez) - species code 149 (category LR)

Scientific name: Parasudis truculenta

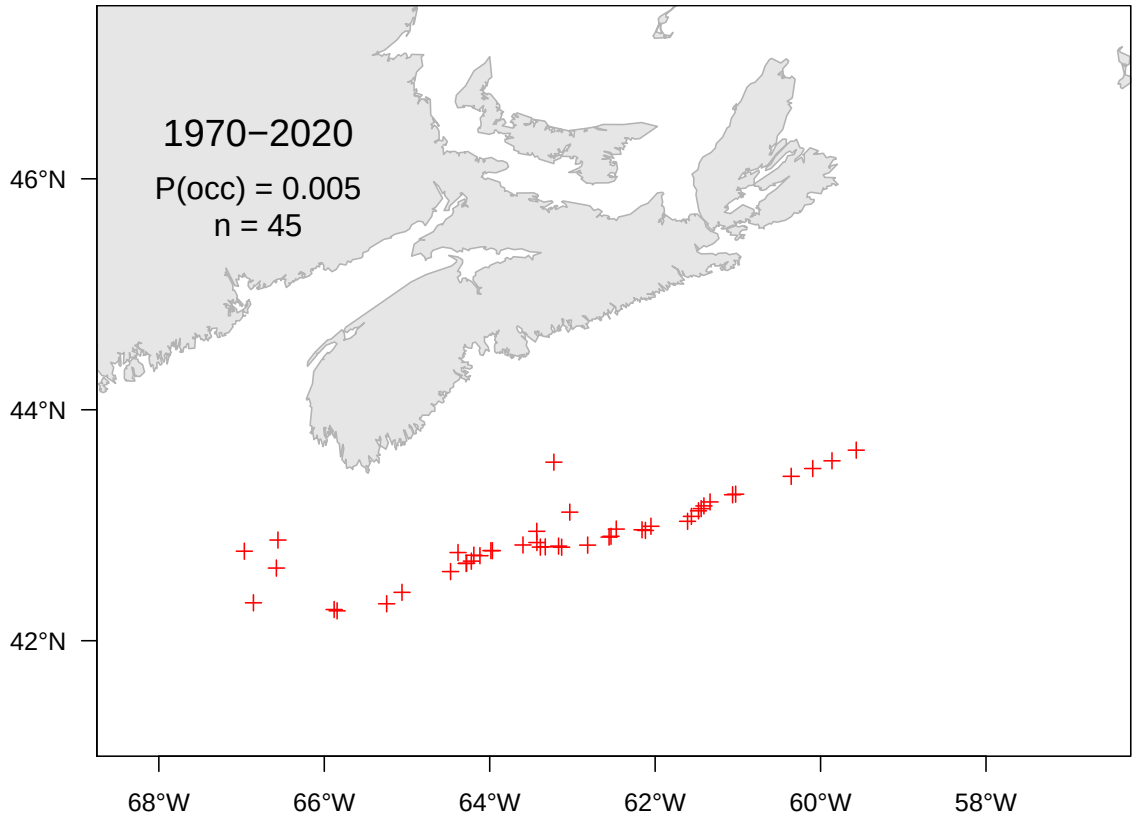


Figure 7.68A. Catch distribution for Longnose greeneye.

7.69 Lanternfishes (Poissons-lanternes) - species code 150 (category LR)

Scientific name: Myctophidae

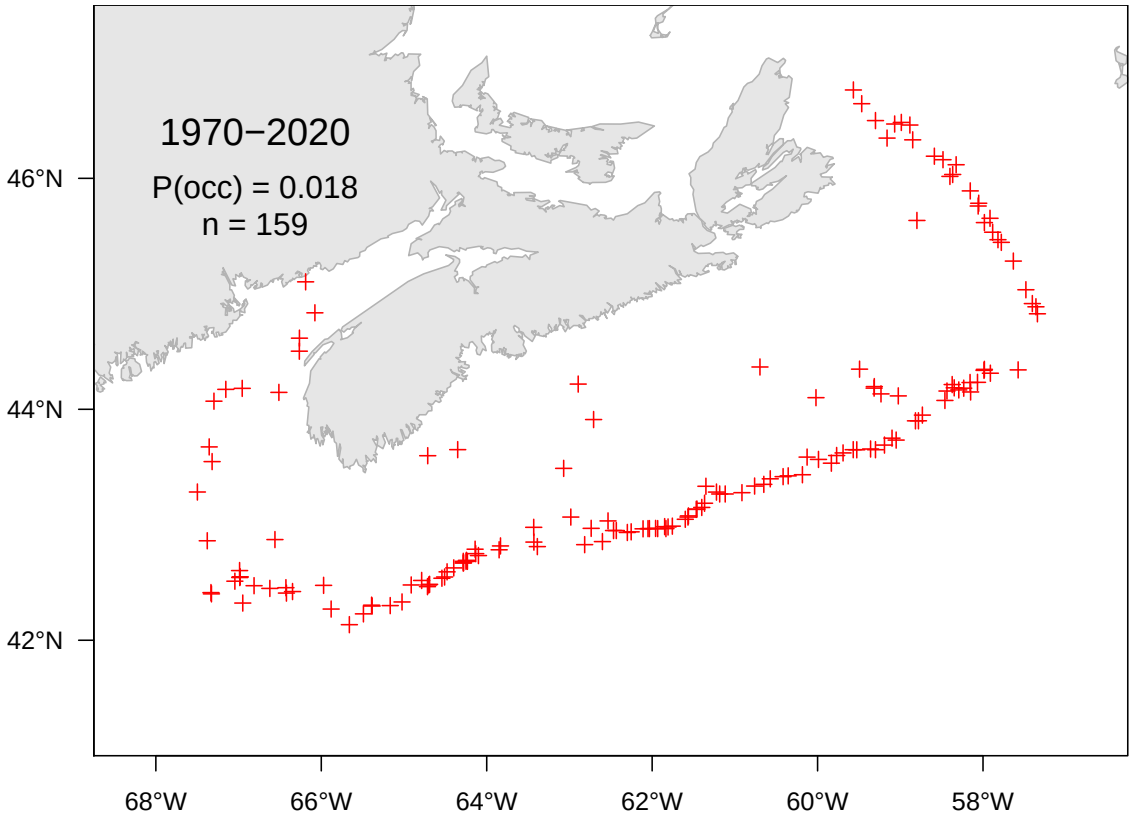


Figure 7.69A. Catch distribution for Lanternfishes.

7.70 Shortnose greeneye (Éperlan du large) - species code 156 (category LR)

Scientific name: Chlorophthalmus agassizi

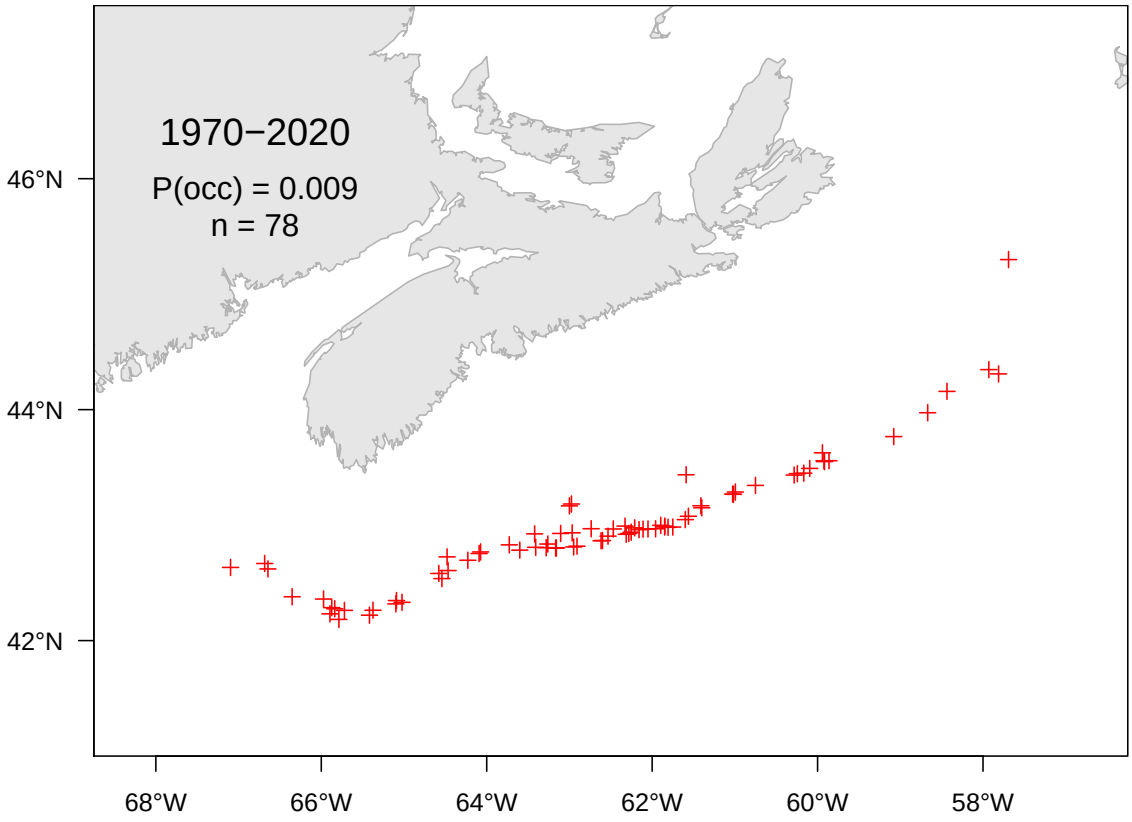


Figure 7.70A. Catch distribution for Shortnose greeneye.

7.71 Silvery lightfish (Brossé améthyste) - species code 158 (category LR)

Scientific name: Maurolicus muelleri

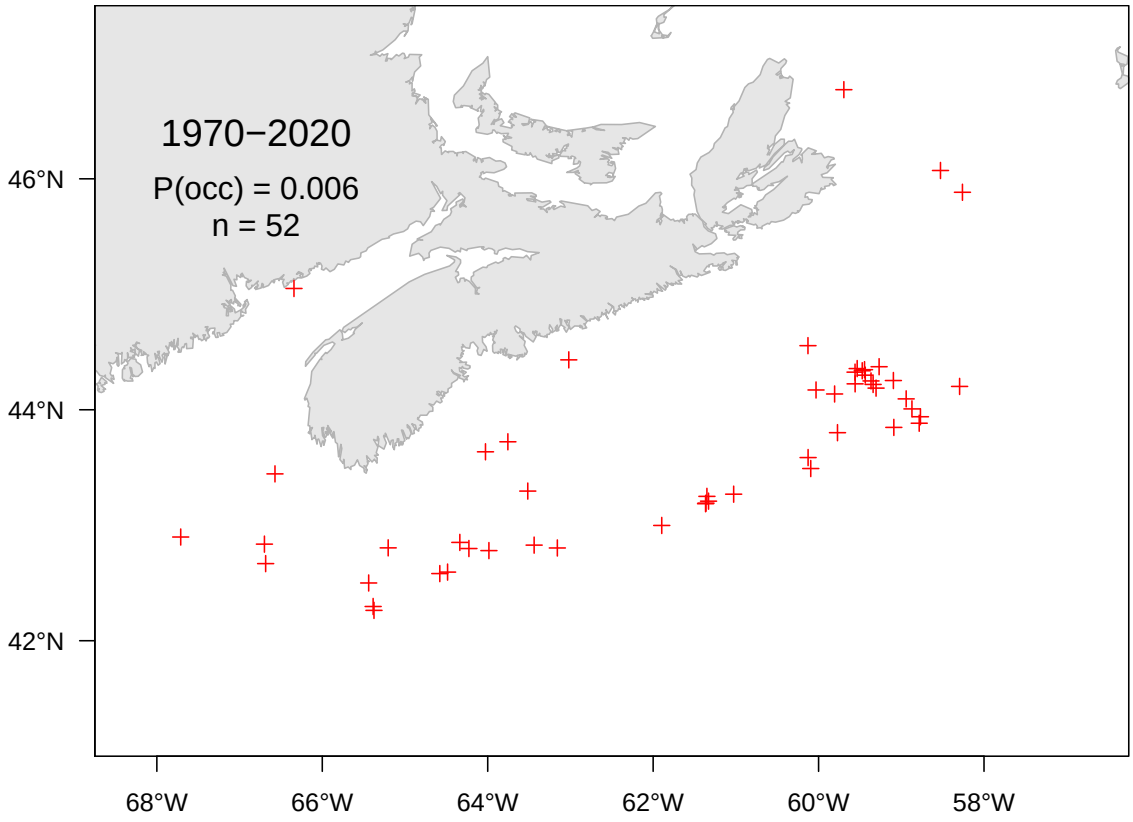


Figure 7.71A. Catch distribution for Silvery lightfish.

7.72 Boa dragonfish (Dragon-boa) - species code 159 (category LR)

Scientific name: Stomias boa

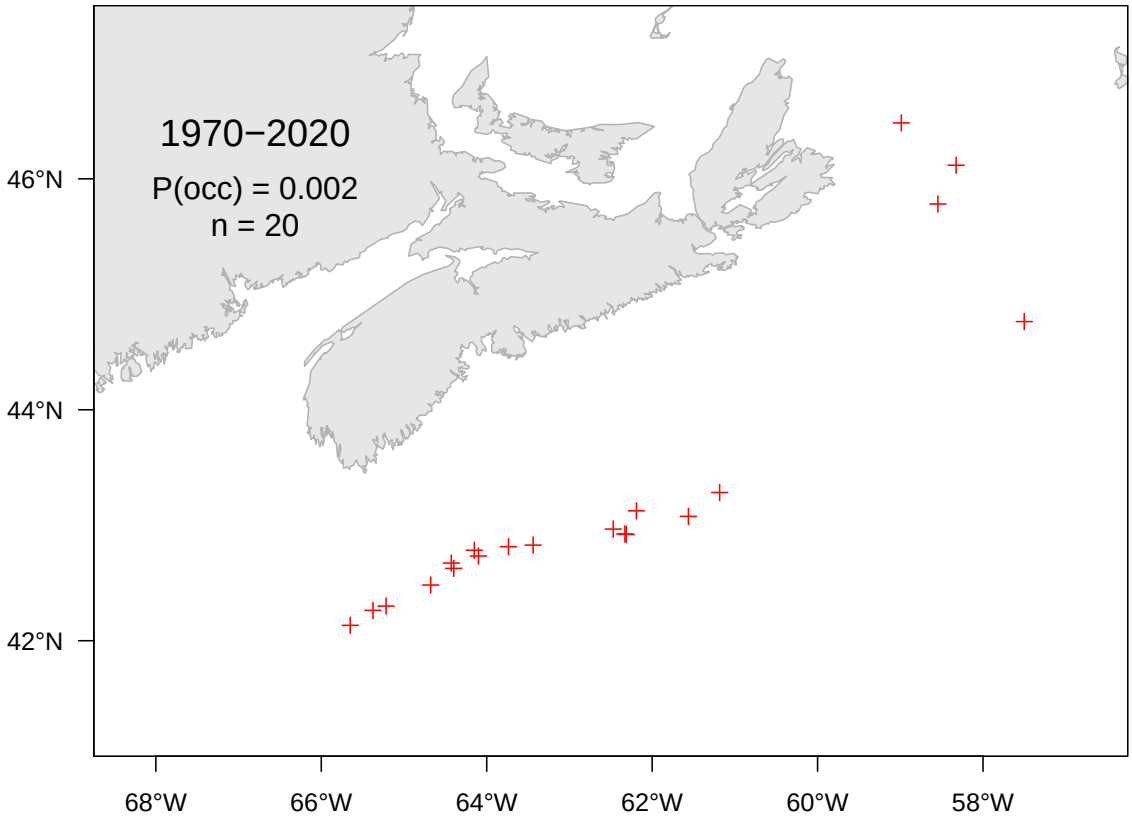


Figure 7.72A. Catch distribution for Boa dragonfish.

7.73 Shorthorn sculpin (Chaboisseau à épines courtes) - species code 301 (category LR)

Scientific name: Myoxocephalus scorpius

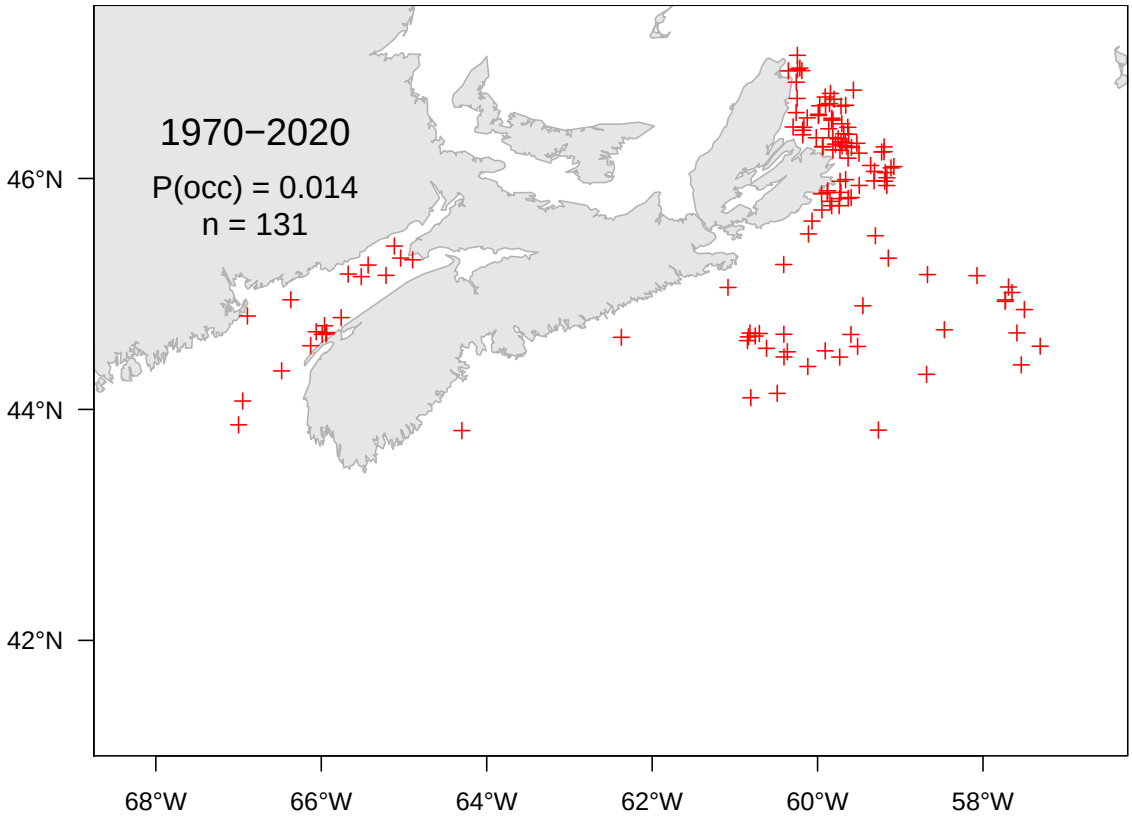


Figure 7.73A. Catch distribution for Shorthorn sculpin.

7.74 Grubby (Chaboisseau bronzé) - species code 303 (category LR)

Scientific name: Myoxocephalus aenaeus

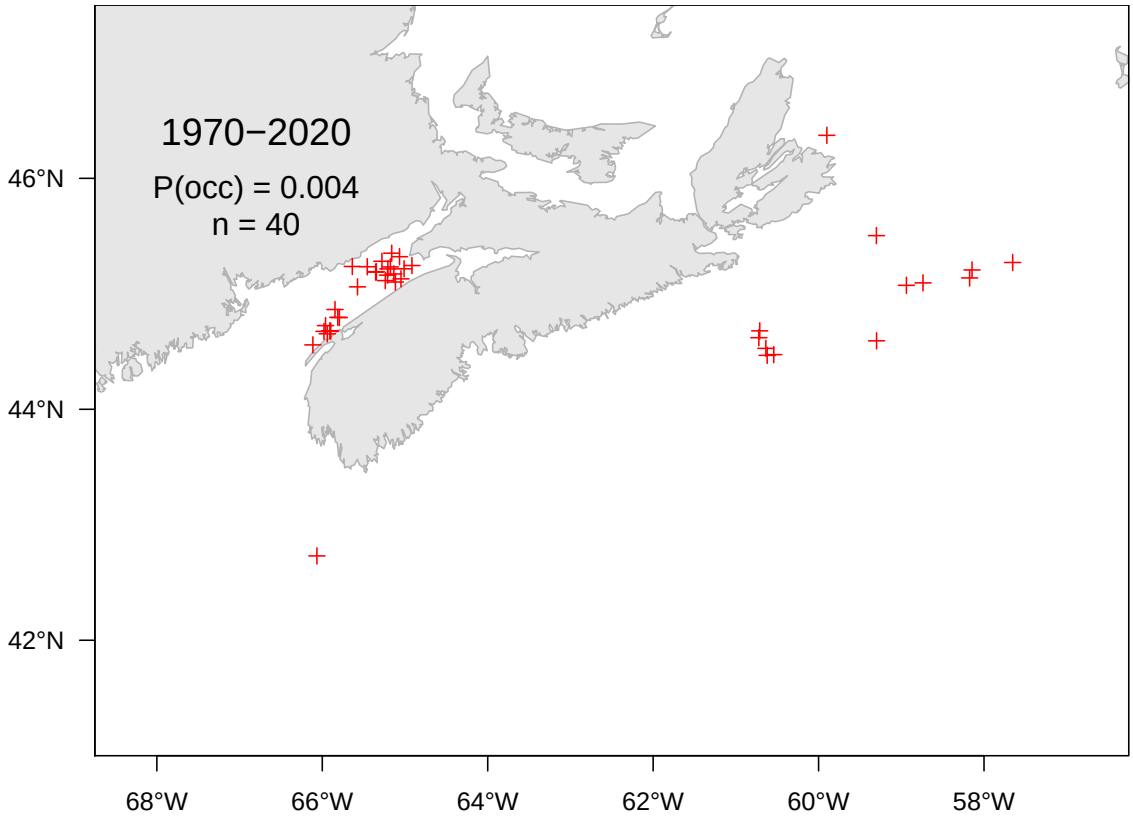


Figure 7.74A. Catch distribution for Grubby.

7.75 Polar sculpin (Cotte polaire) - species code 307 (category LR)

Scientific name: Cottunculus microps

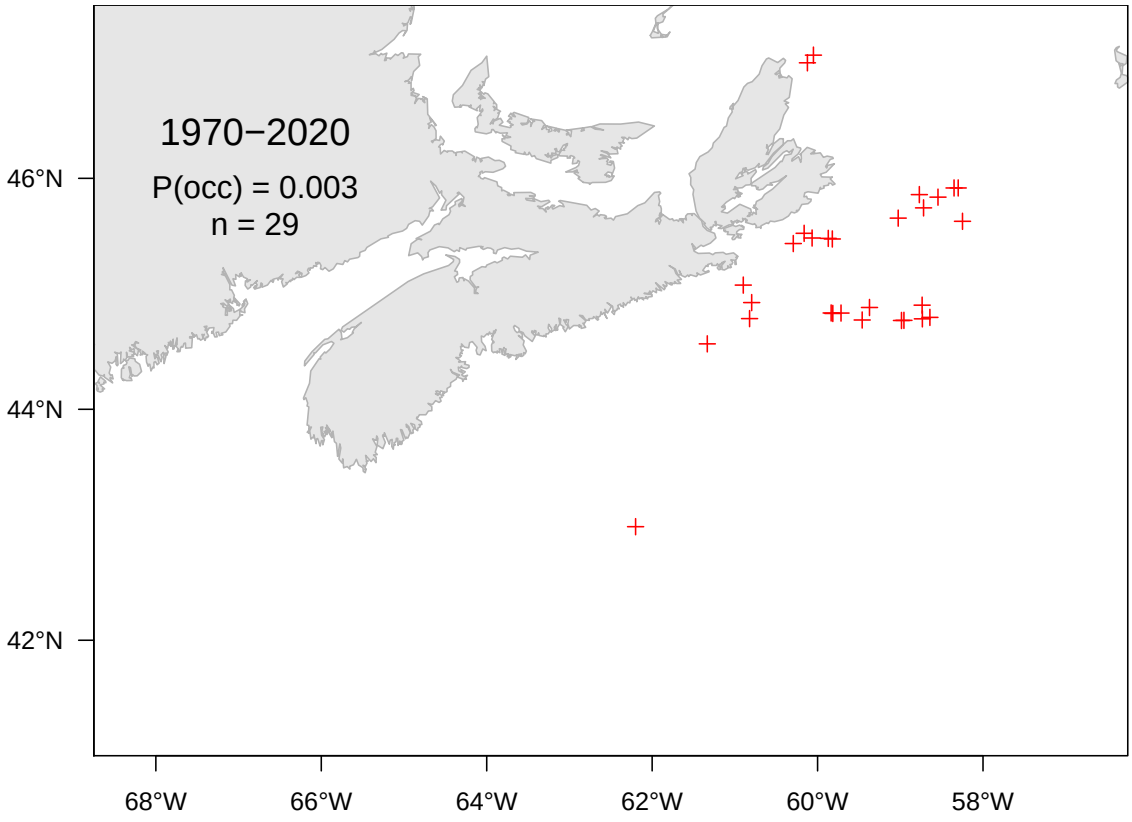


Figure 7.75A. Catch distribution for Polar sculpin.

7.76 Spatulate sculpin (Icèle spatulée) - species code 314 (category LR)

Scientific name: Icelus spatula

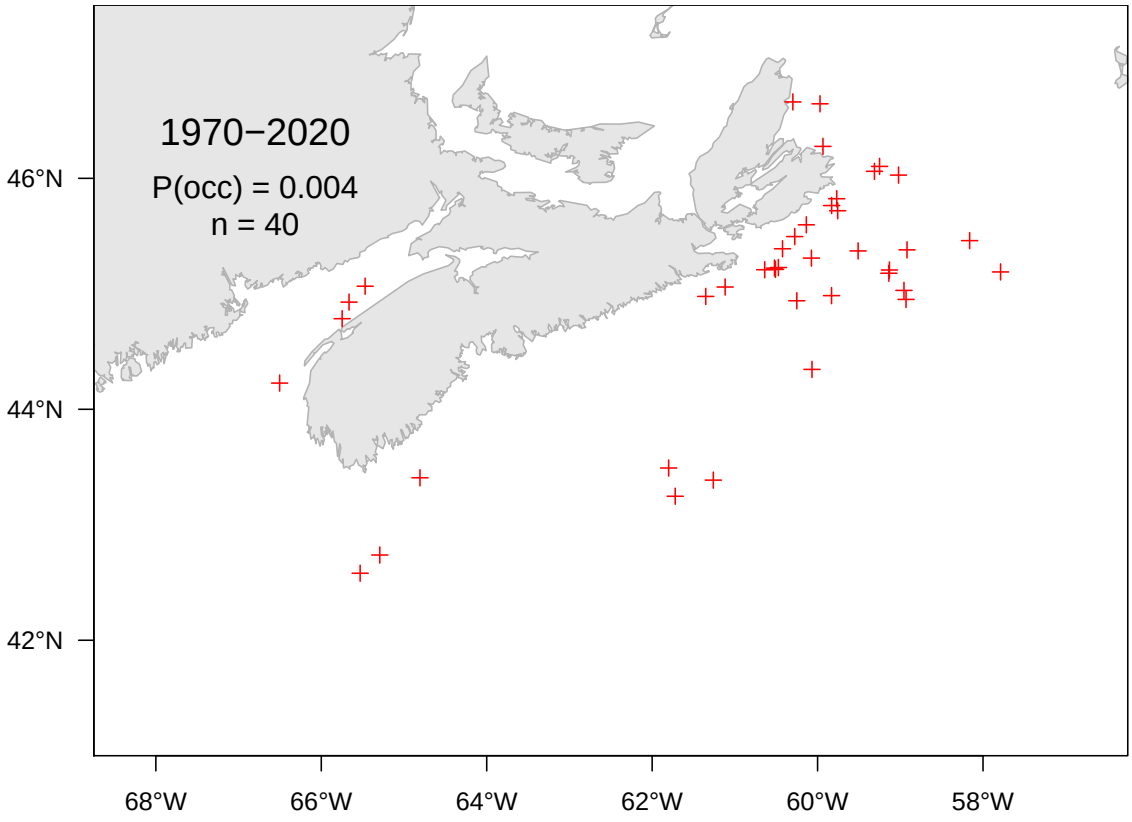


Figure 7.76A. Catch distribution for Spatulate sculpin.

7.77 Arctic alligatorfish (Poisson-alligator arctique) - species code 341 (category LR)

Scientific name: Ulcina olrikii

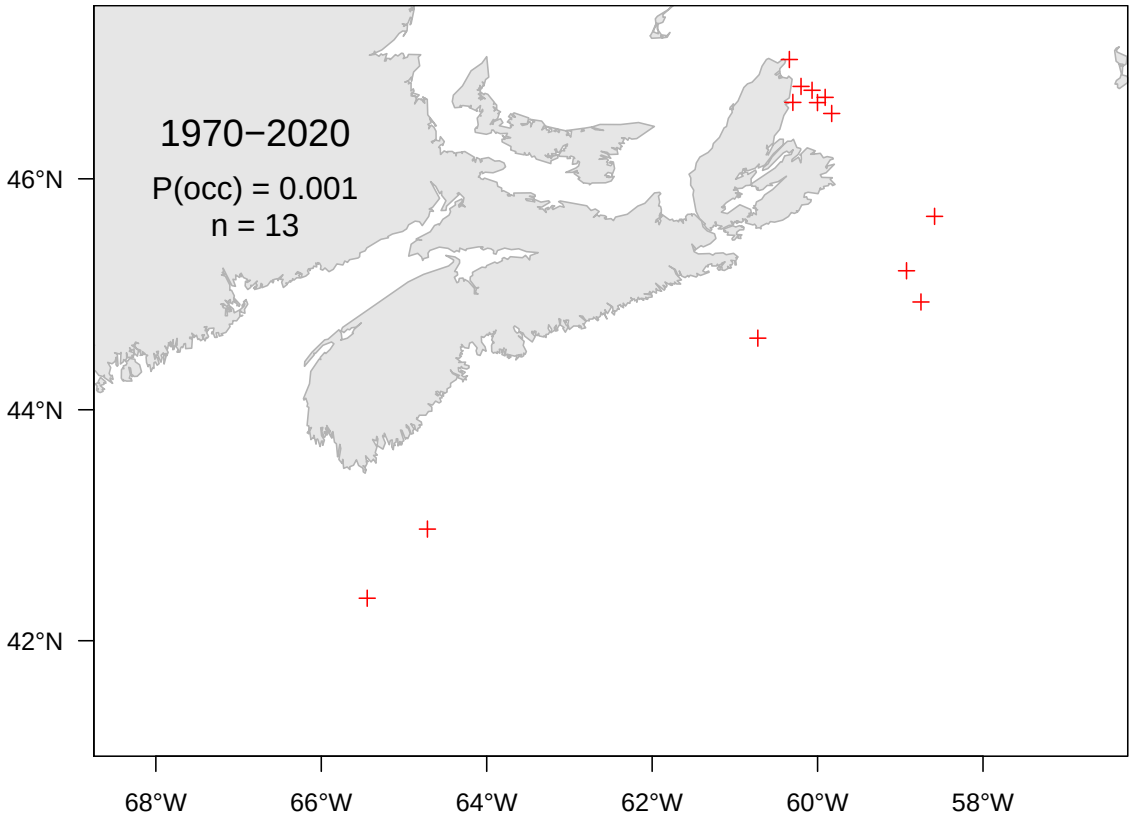


Figure 7.77A. Catch distribution for Arctic alligatorfish.

7.78 Alligatorfishes (Poissons-alligator) - species code 351 (category LR)

Scientific name: Agonidae

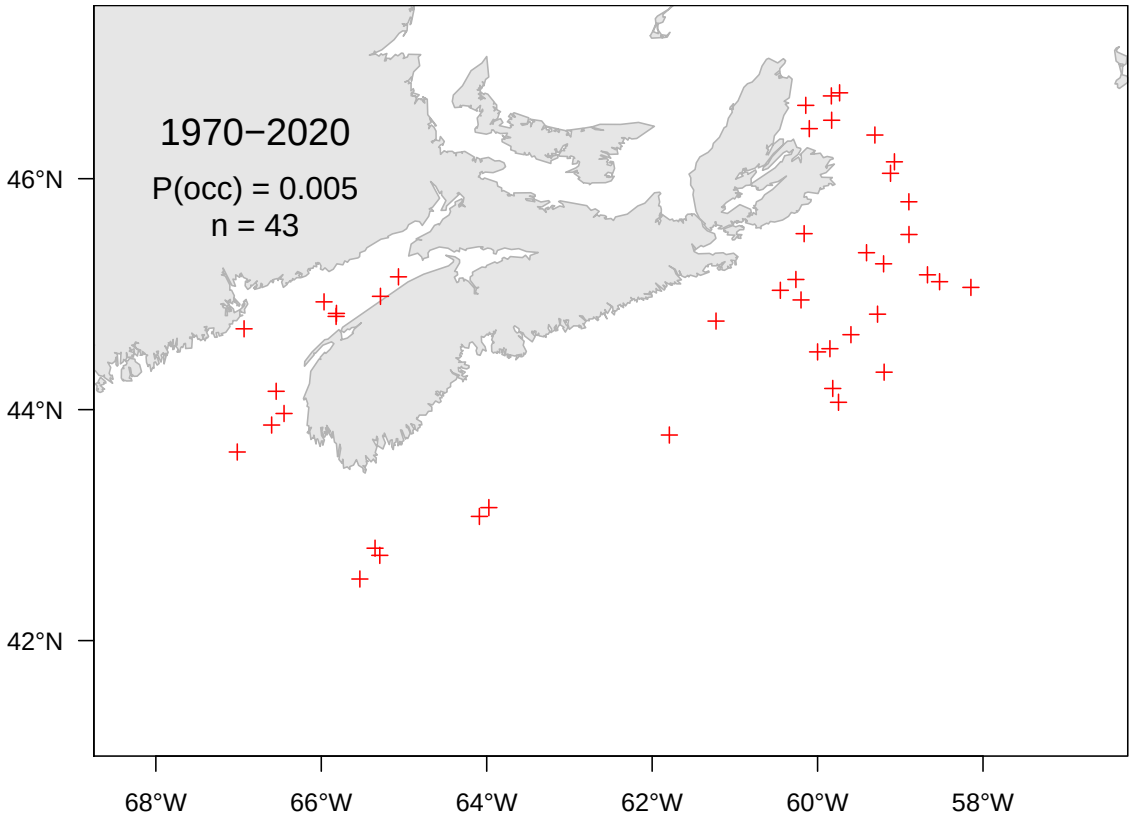


Figure 7.78A. Catch distribution for Alligatorfishes.

7.79 Roughnose grenadier (Grenadier-scie) - species code 412 (category LR)

Scientific name: Trachyrincus murrayi

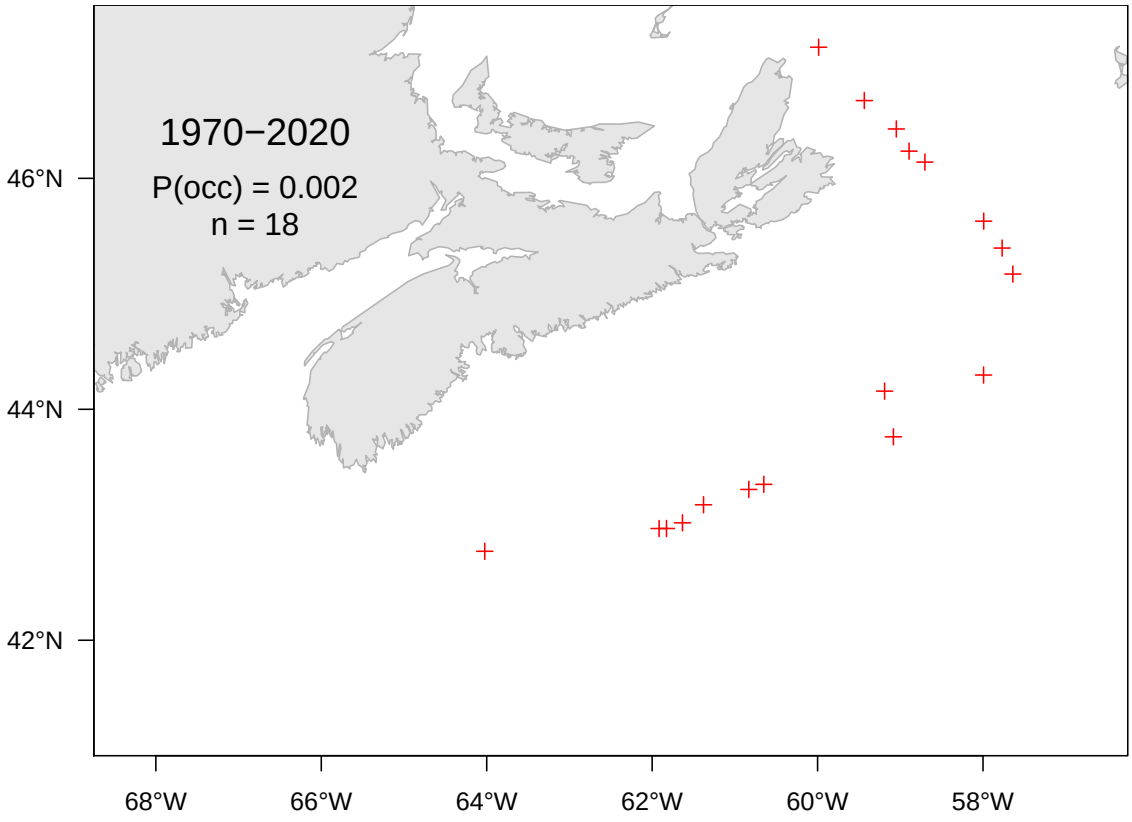


Figure 7.79A. Catch distribution for Roughnose grenadier.

7.80 Roundnose grenadier (Grenadier de roche) - species code 414 (category LR)

Scientific name: Coryphaenoides rupestris

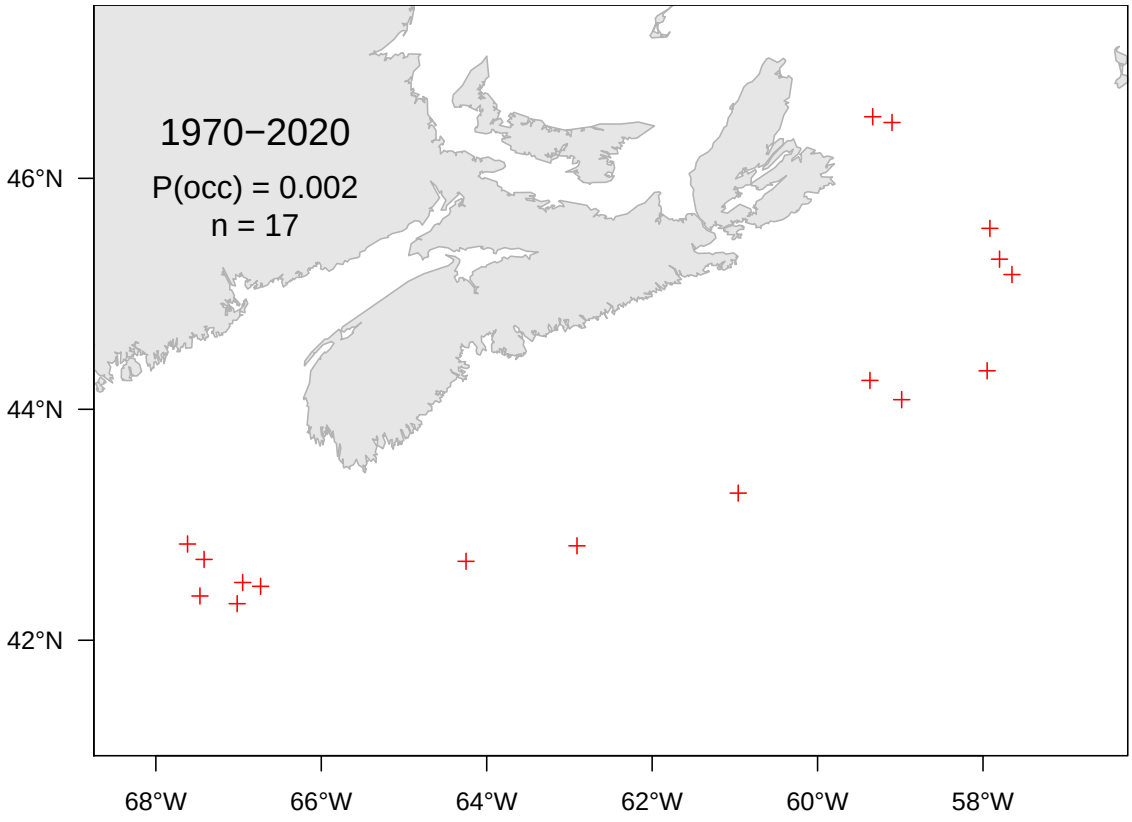


Figure 7.80A. Catch distribution for Roundnose grenadier.

7.81 Atlantic seasnail (Limace atlantique) - species code 503 (category LR)

Scientific name: Liparis atlanticus

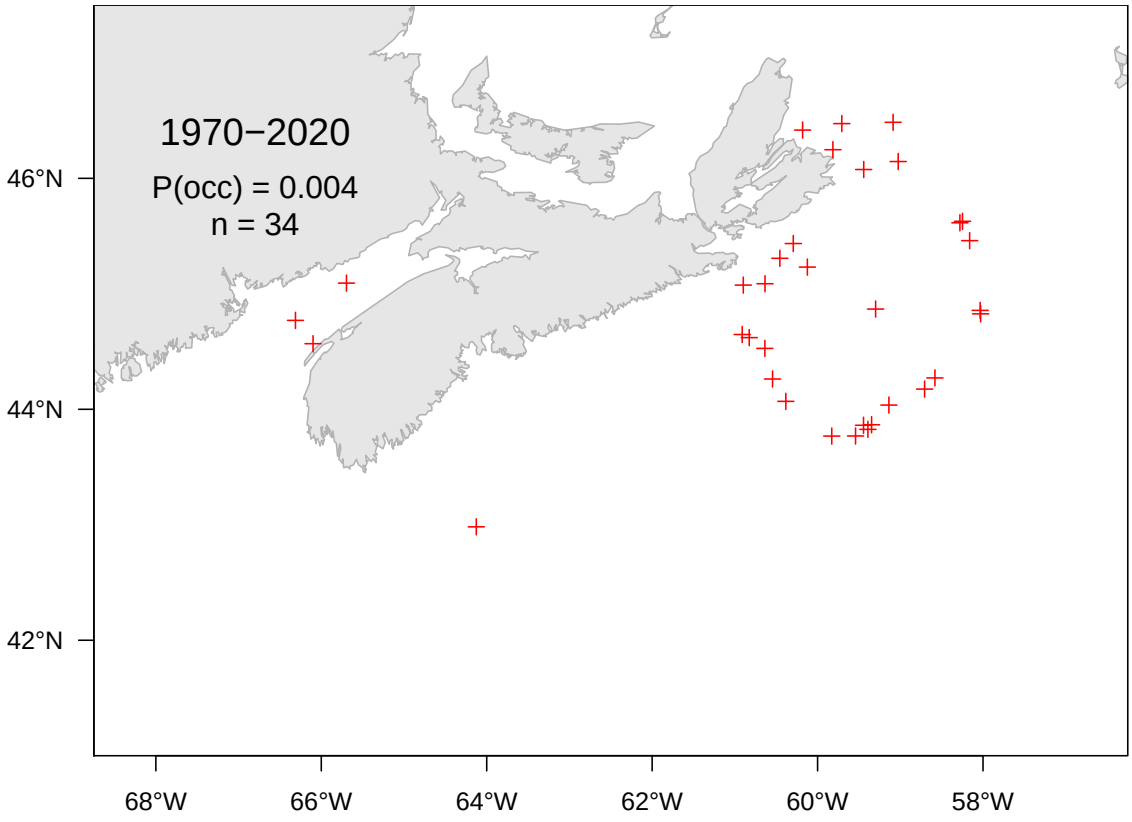


Figure 7.81A. Catch distribution for Atlantic seasnail.

7.82 Gelatinous snailfish (Limace gélatineuse) - species code 505 (category LR)

Scientific name: Liparis fabricii

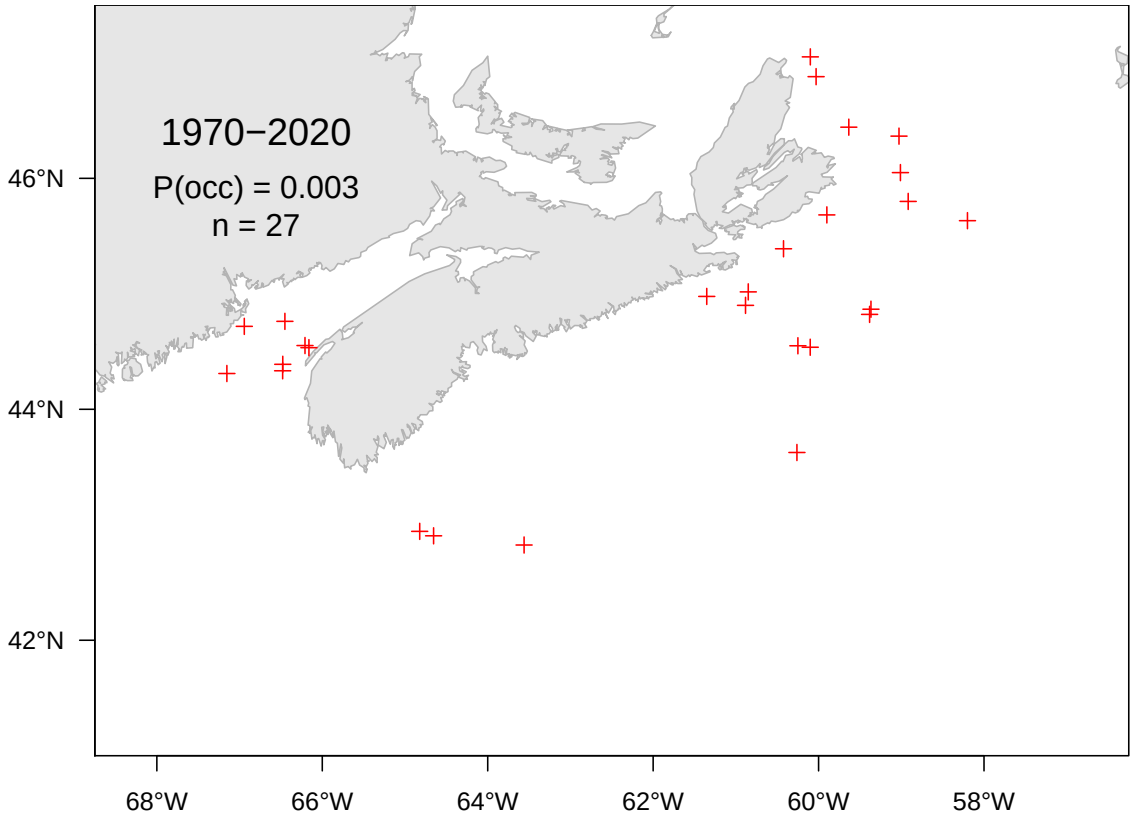


Figure 7.82A. Catch distribution for Gelatinous snailfish.

7.83 Variegated snailfish (Limace marbée) - species code 512 (category LR)

Scientific name: Liparis gibbus

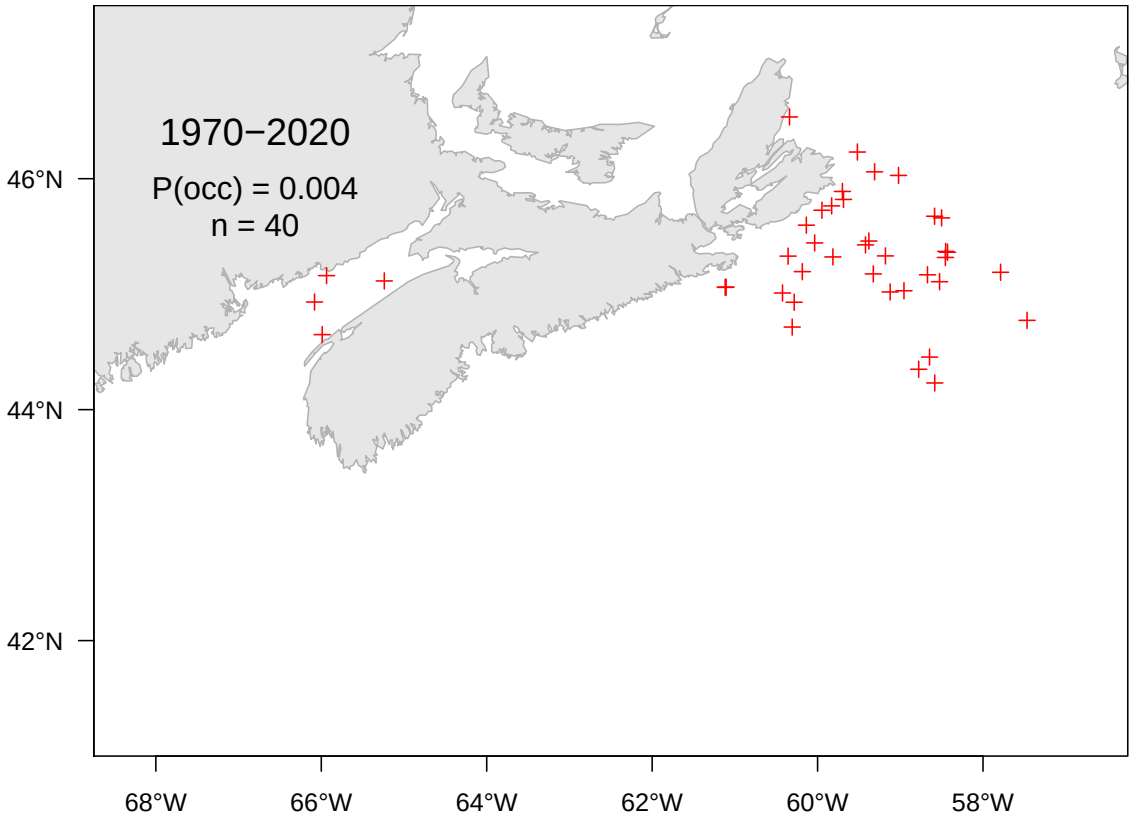


Figure 7.83A. Catch distribution for Variegated snailfish.

7.84 Sea tadpole (Petite limace de mer) - species code 520 (category LR)

Scientific name: Careproctus reinhardti

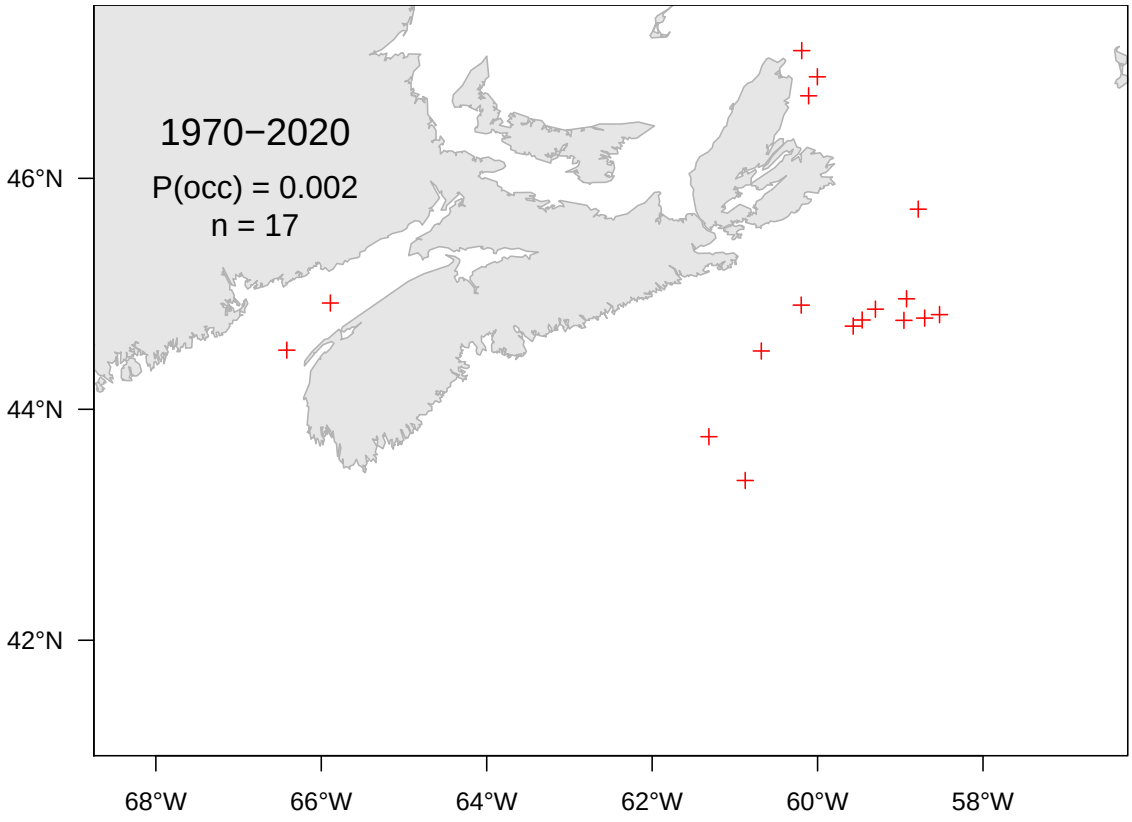


Figure 7.84A. Catch distribution for Sea tadpole.

7.85 Wolf eelpout (Lycode à tête longue) - species code 603 (category LR)

Scientific name: Lycenchelys verrillii

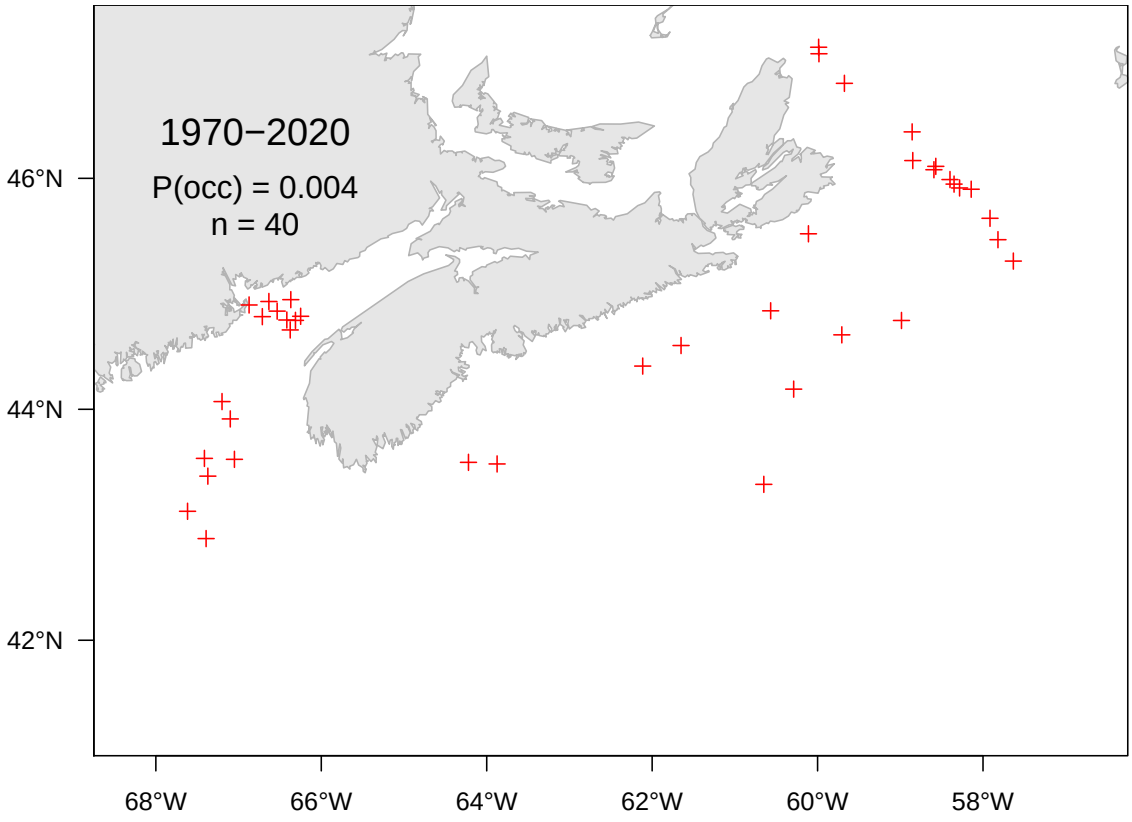


Figure 7.85A. Catch distribution for Wolf eelpout.

7.86 Slender snipe eel (Avocette ruban) - species code 604 (category LR)

Scientific name: Nemichthys scolopaceus

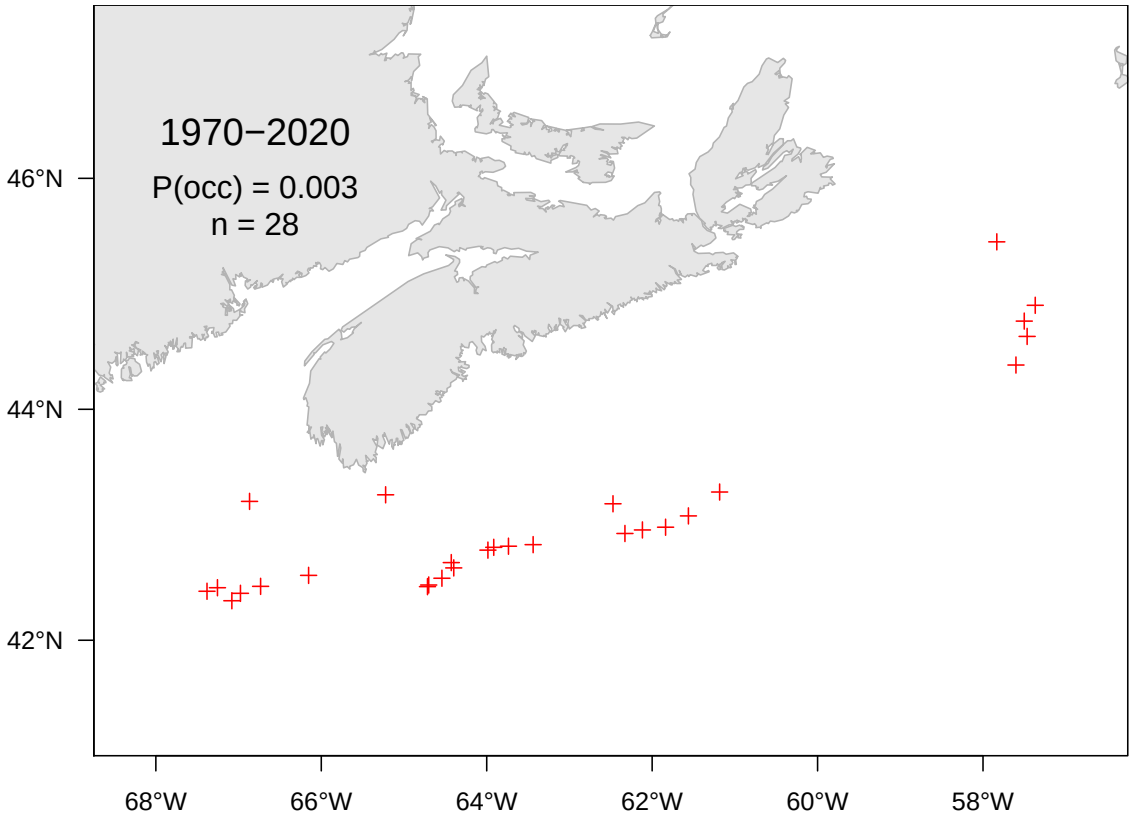


Figure 7.86A. Catch distribution for Slender snipe eel.

7.87 Newfoundland eelpout (Lycode du Labrador) - species code 619 (category LR)

Scientific name: Lycodes terraenovae

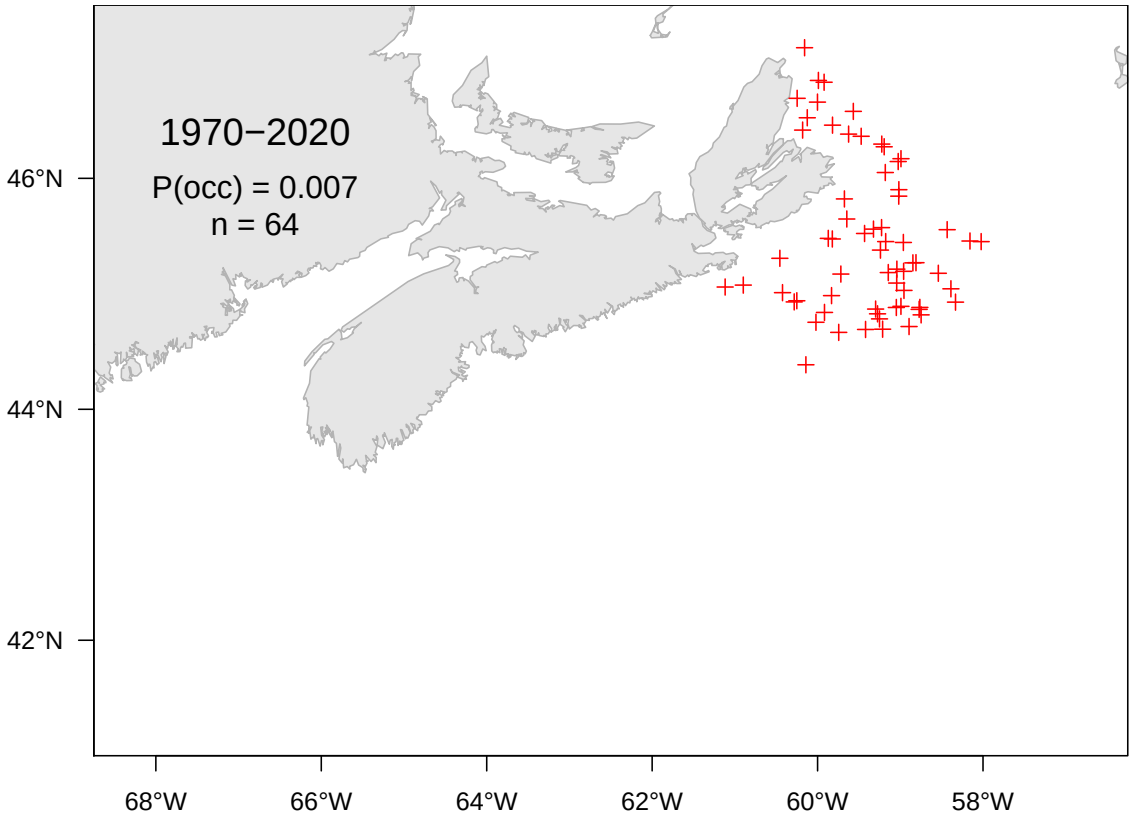


Figure 7.87A. Catch distribution for Newfoundland eelpout.

7.88 Newfoundland eelpout (Lycode du Labrador) - species code 620 (category LR)

Scientific name: Lycodes lavalaei

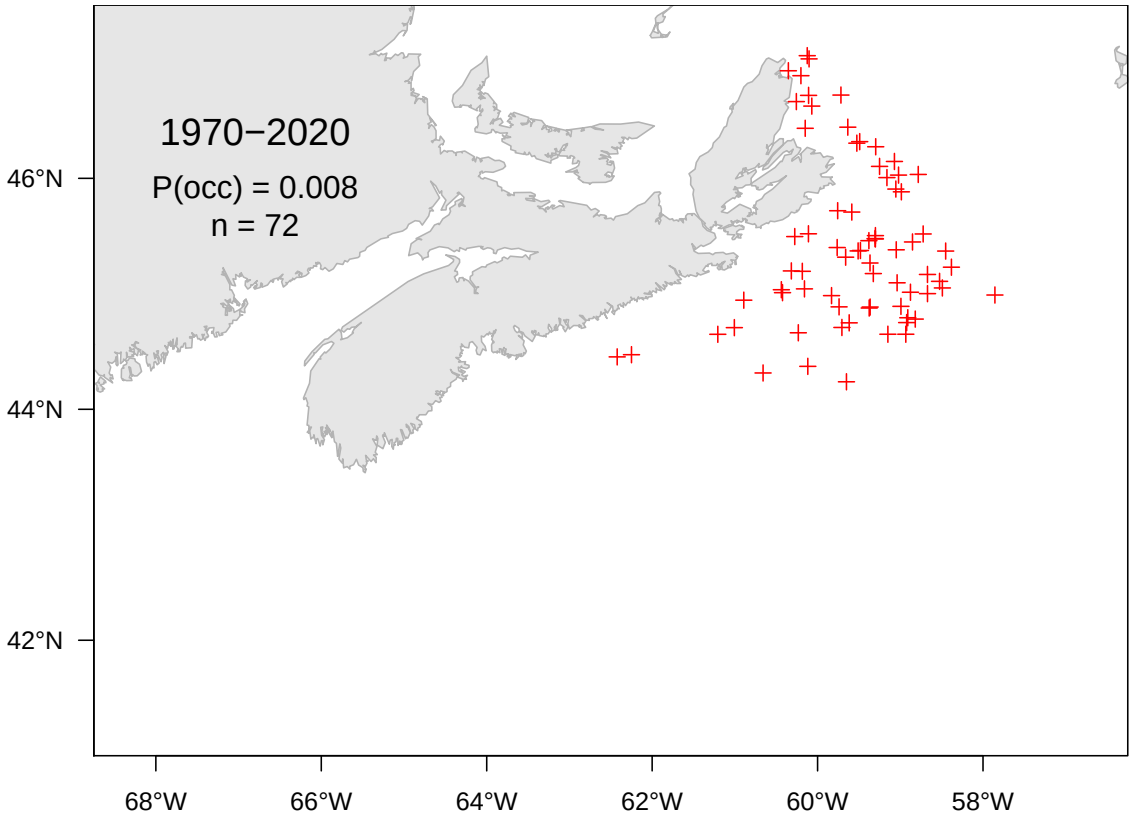


Figure 7.88A. Catch distribution for Newfoundland eelpout.

7.89 Rock gunnel (Sigouine de roche) - species code 621 (category LR)

Scientific name: Pholis gunnellus

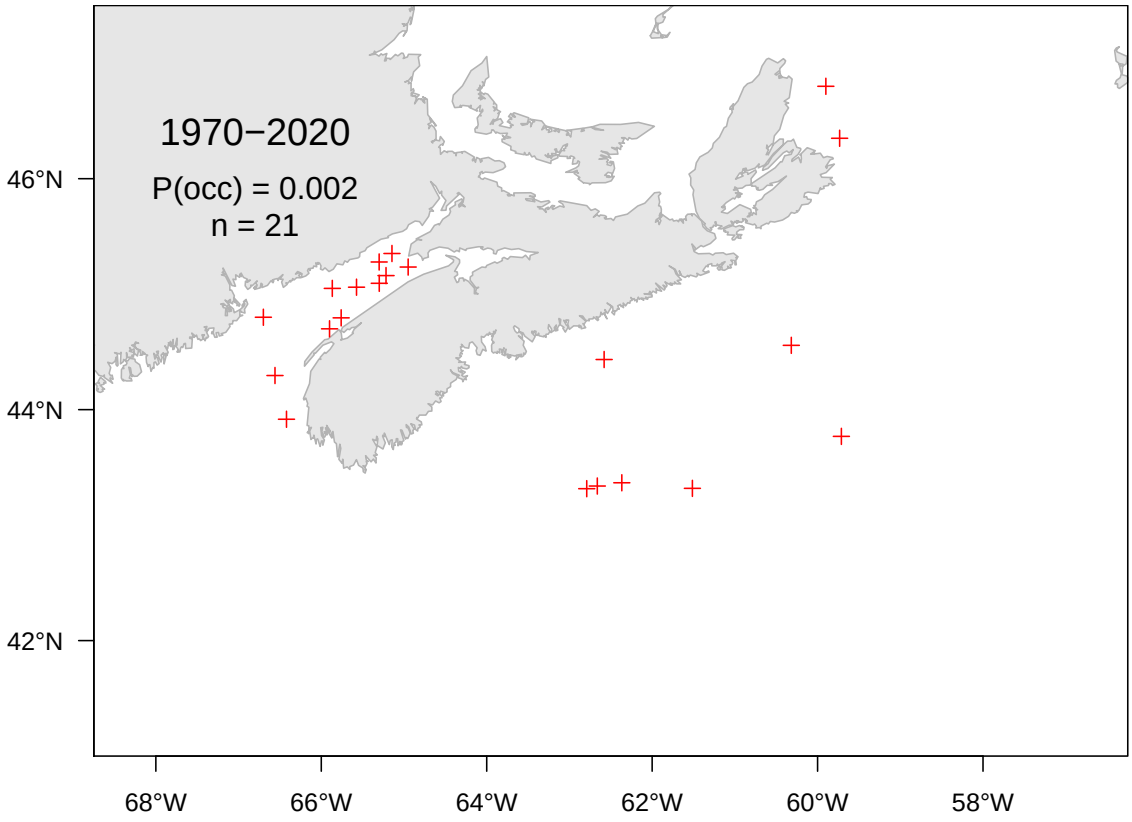


Figure 7.89A. Catch distribution for Rock gunnel.

7.90 Radiated shanny (Ulvaire deux-lignes) - species code 625 (category LR)

Scientific name: Ulvaria subbifurcata

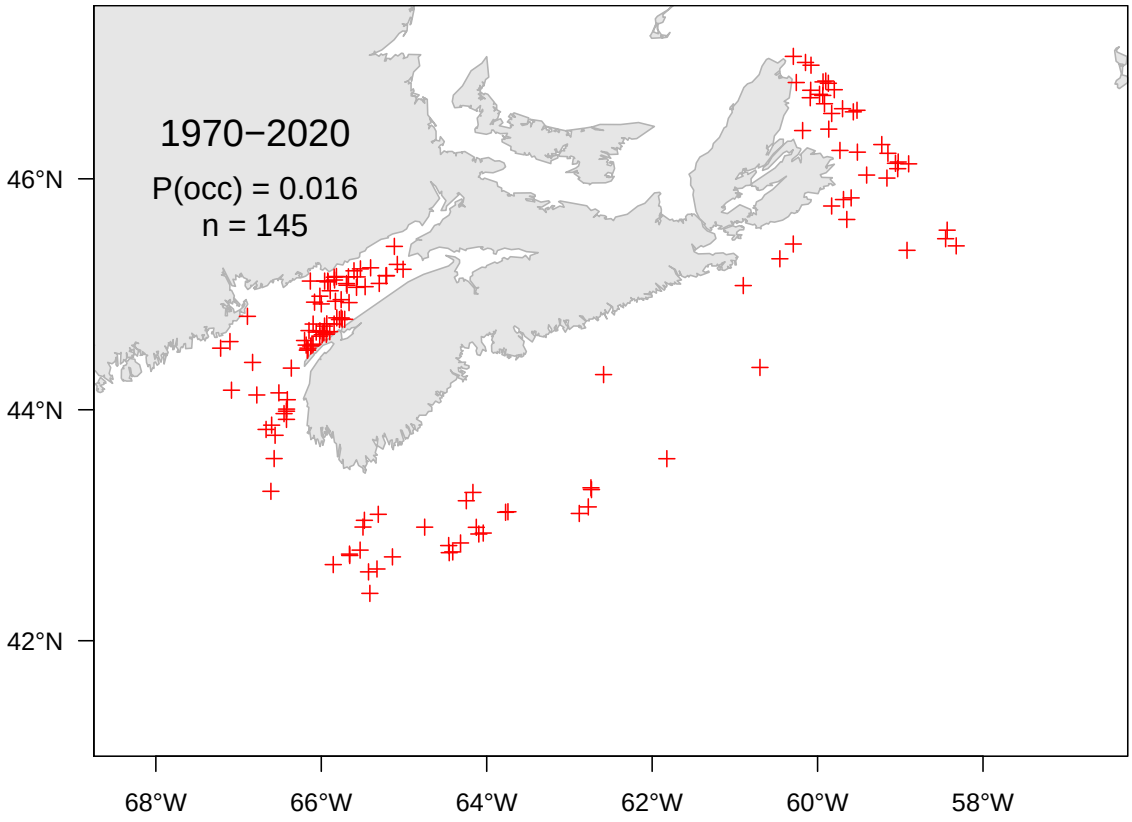


Figure 7.90A. Catch distribution for Radiated shanny.

7.91 Fourline snakeblenny (Quatre-lignes atlantique) - species code 626 (category LR)

Scientific name: Eumesogrammus praecisus

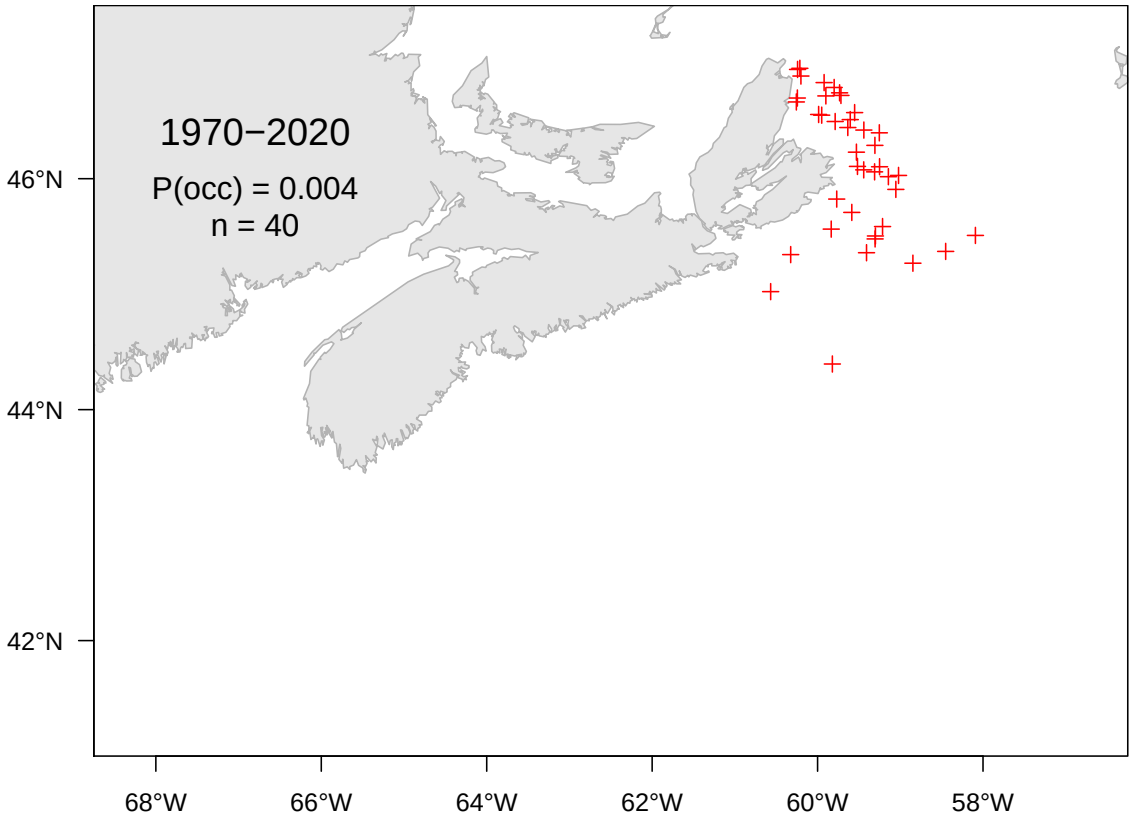


Figure 7.91A. Catch distribution for Fourline snakeblenny.

7.92 Wrymouth (Terrassier tacheté) - species code 630 (category LR)

Scientific name: Cryptacanthodes maculatus

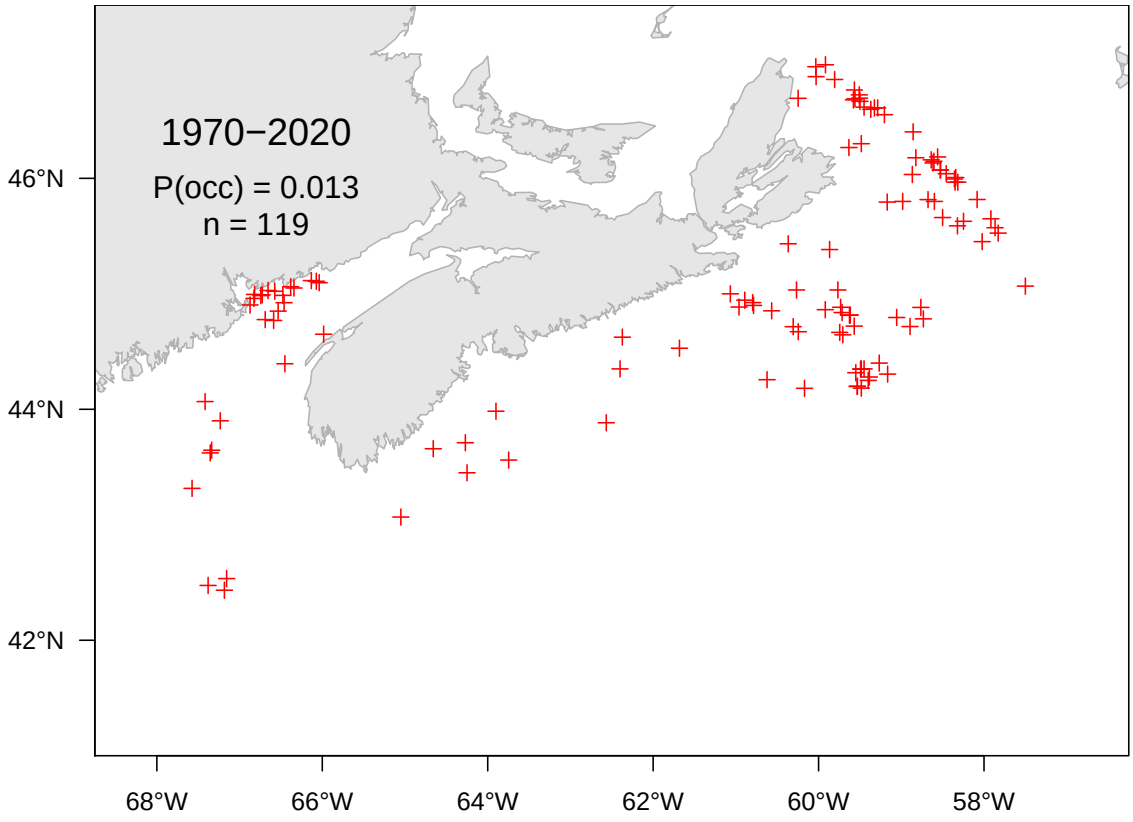


Figure 7.92A. Catch distribution for Wrymouth.

7.93 Spotfin dragonet (Dragonnet tacheté) - species code 637 (category LR)

Scientific name: Foetorepus agassizii

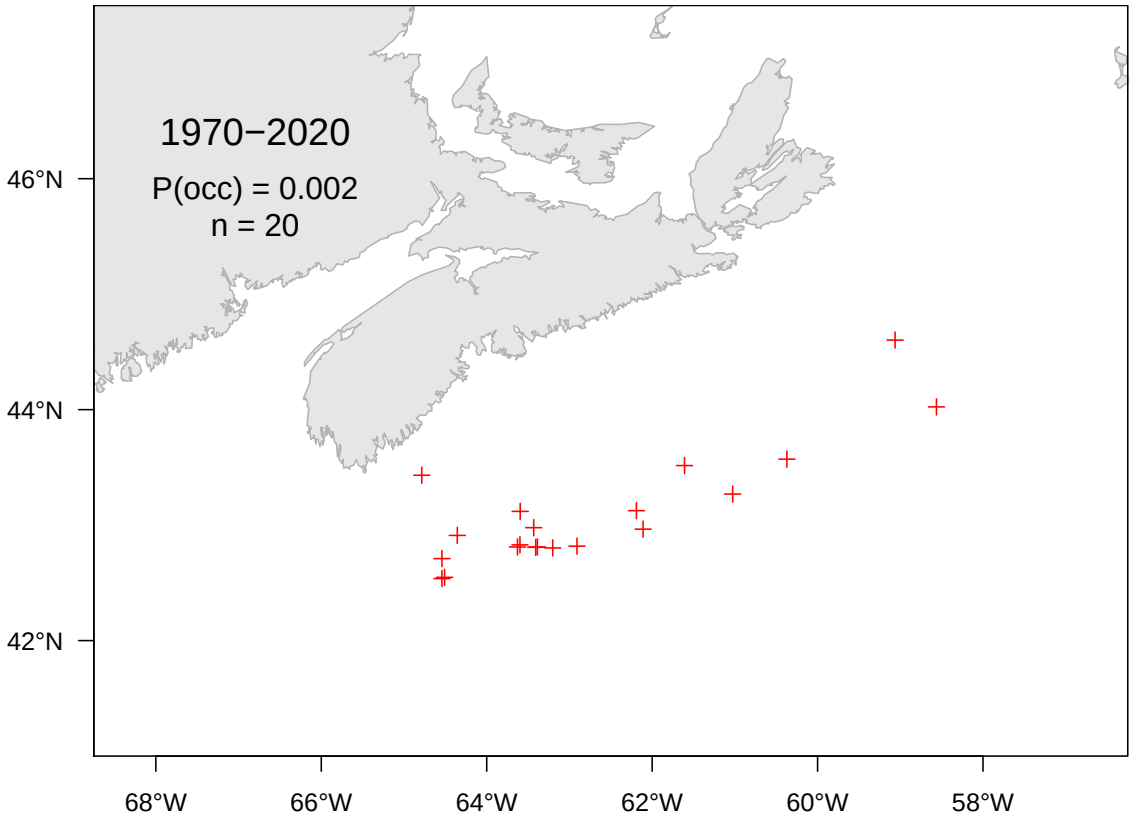


Figure 7.93A. Catch distribution for Spotfin dragonet.

7.94 Arctic eelpout (Lycode arctique) - species code 641 (category LR)

Scientific name: Lycodes reticulatus

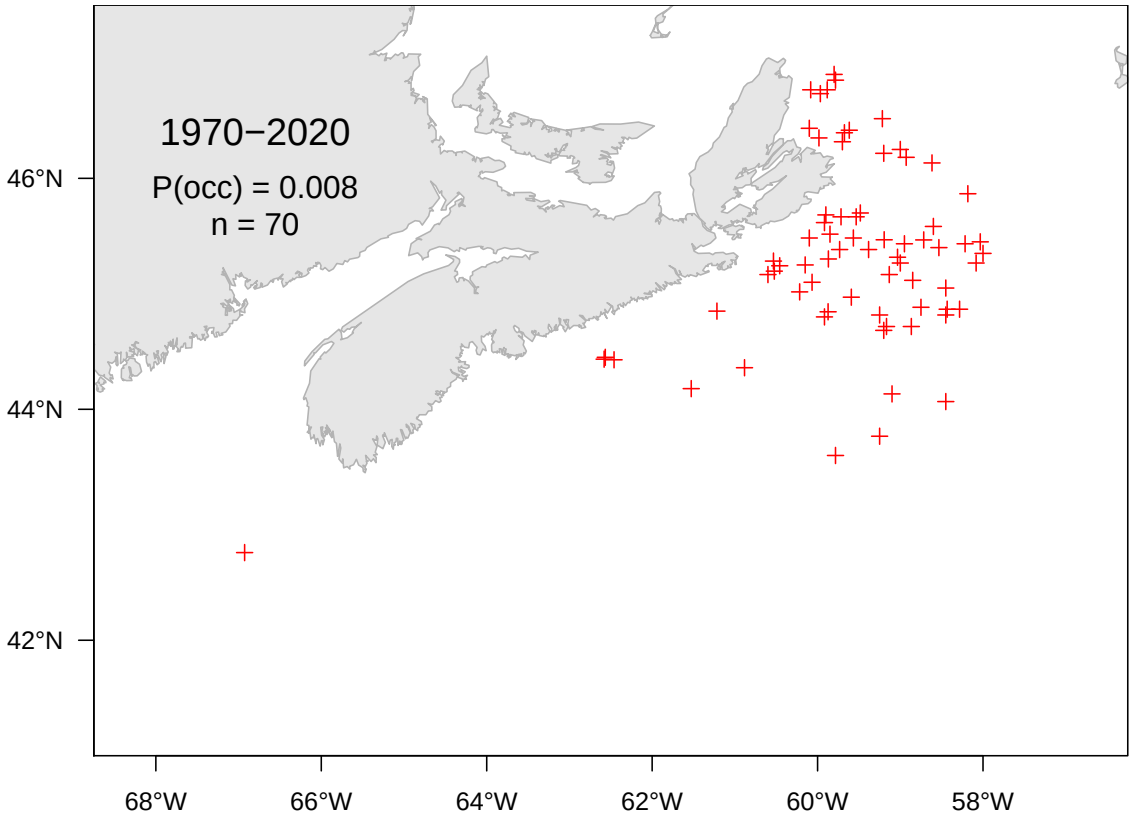


Figure 7.94A. Catch distribution for Arctic eelpout.

7.95 Atlantic soft pout (Molasse atlantique) - species code 646 (category LR)

Scientific name: Melanostigma atlanticum

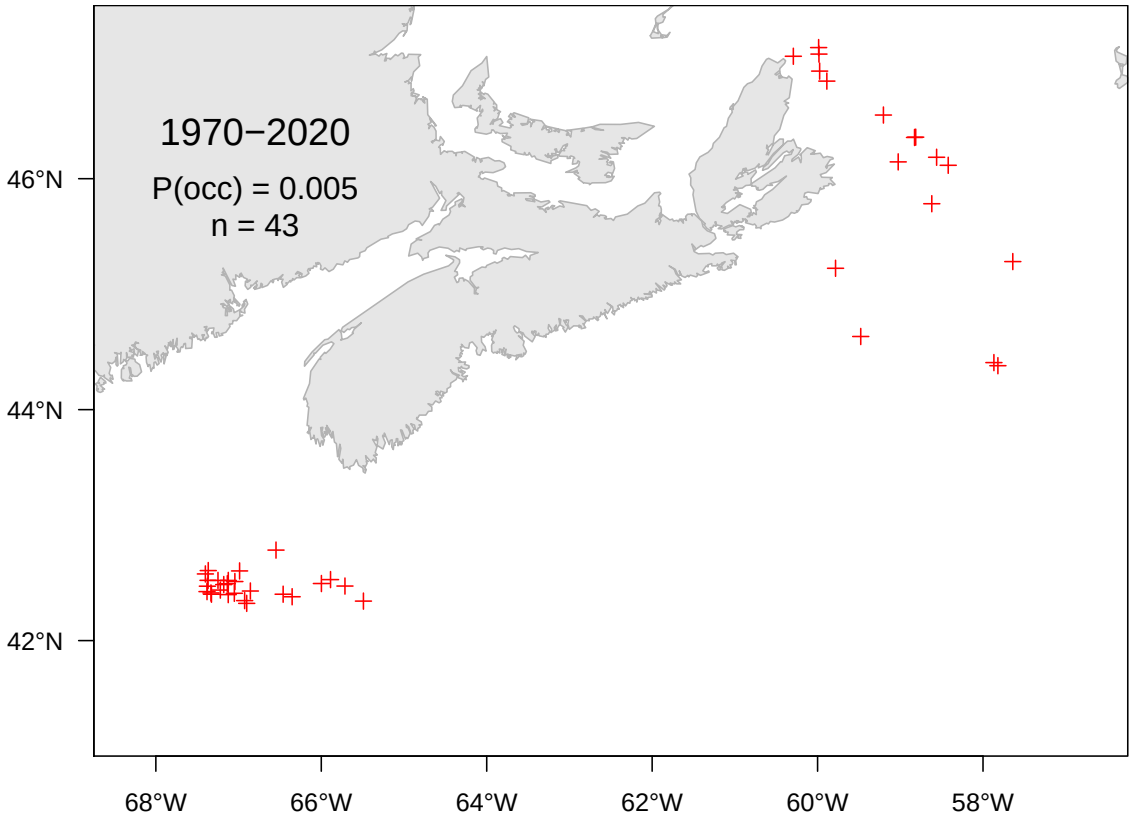


Figure 7.95A. Catch distribution for Atlantic soft pout.

7.96 Silvery John dory (Saint Pierre argenté) - species code 704 (category LR)

Scientific name: Zenopsis conchifer

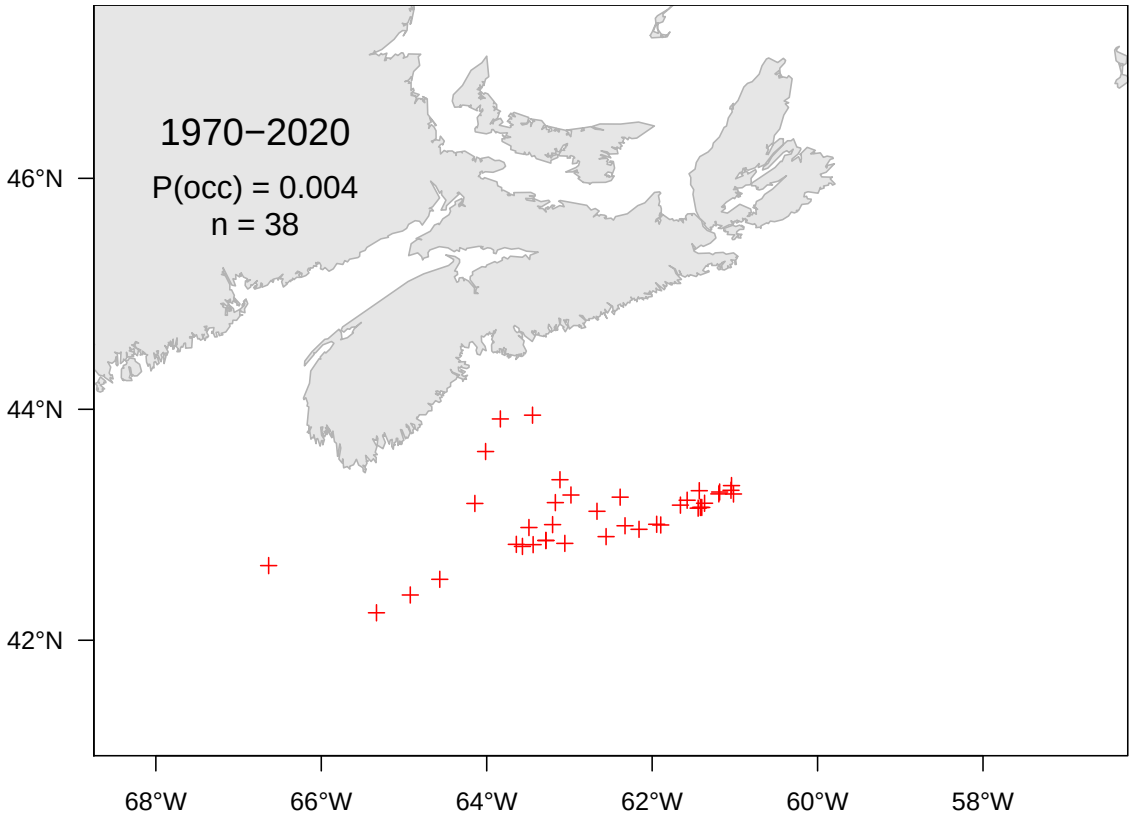


Figure 7.96A. Catch distribution for Silvery John dory.

7.97 White barracudina (Lussion blanc) - species code 712 (category LR)

Scientific name: Arctozenus risso

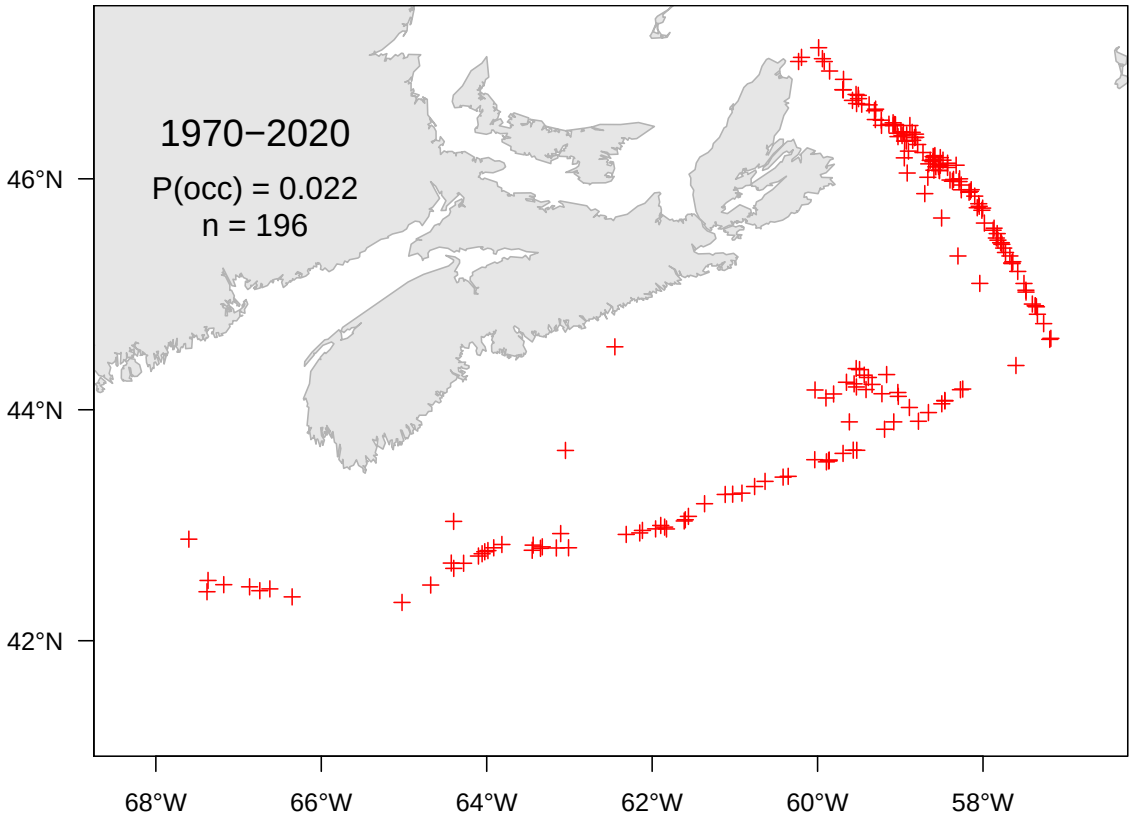


Figure 7.97A. Catch distribution for White barracudina.

7.98 Atlantic saury (Balaou atlantique) - species code 720 (category LR)

Scientific name: Scomberesox saurus

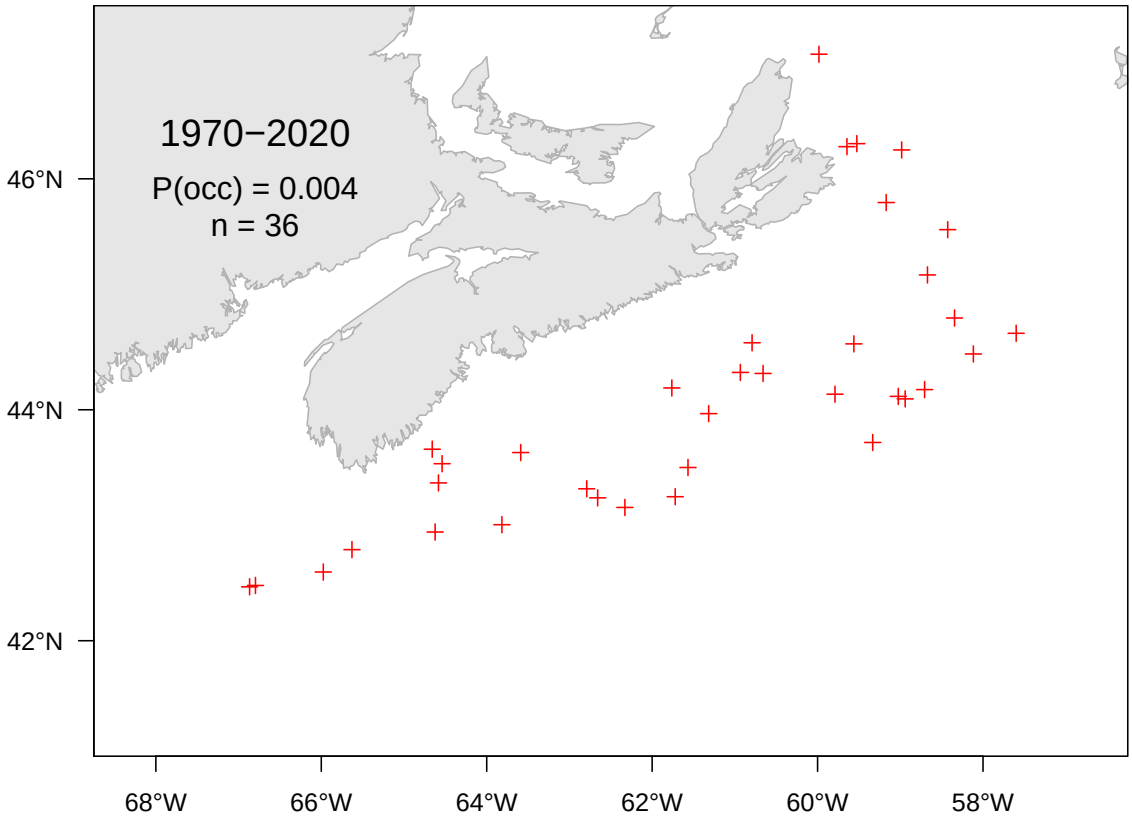


Figure 7.98A. Catch distribution for Atlantic saury.

7.99 Hatchetfishes (Haches d'argent) - species code 741 (category LR)

Scientific name: Sternoptychidae

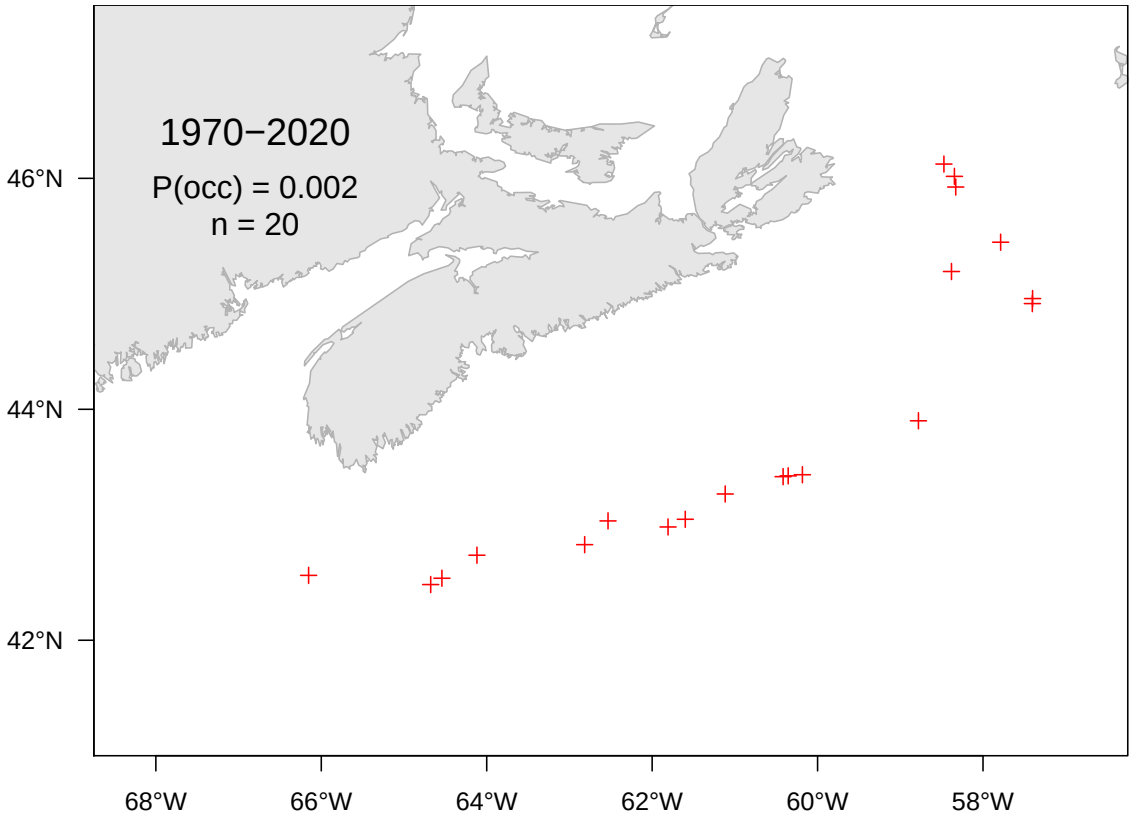


Figure 7.99A. Catch distribution for Hatchetfishes.

7.100 Atlantic batfish (Malthe atlantique) - species code 742 (category LR)

Scientific name: Dibranchus atlanticus

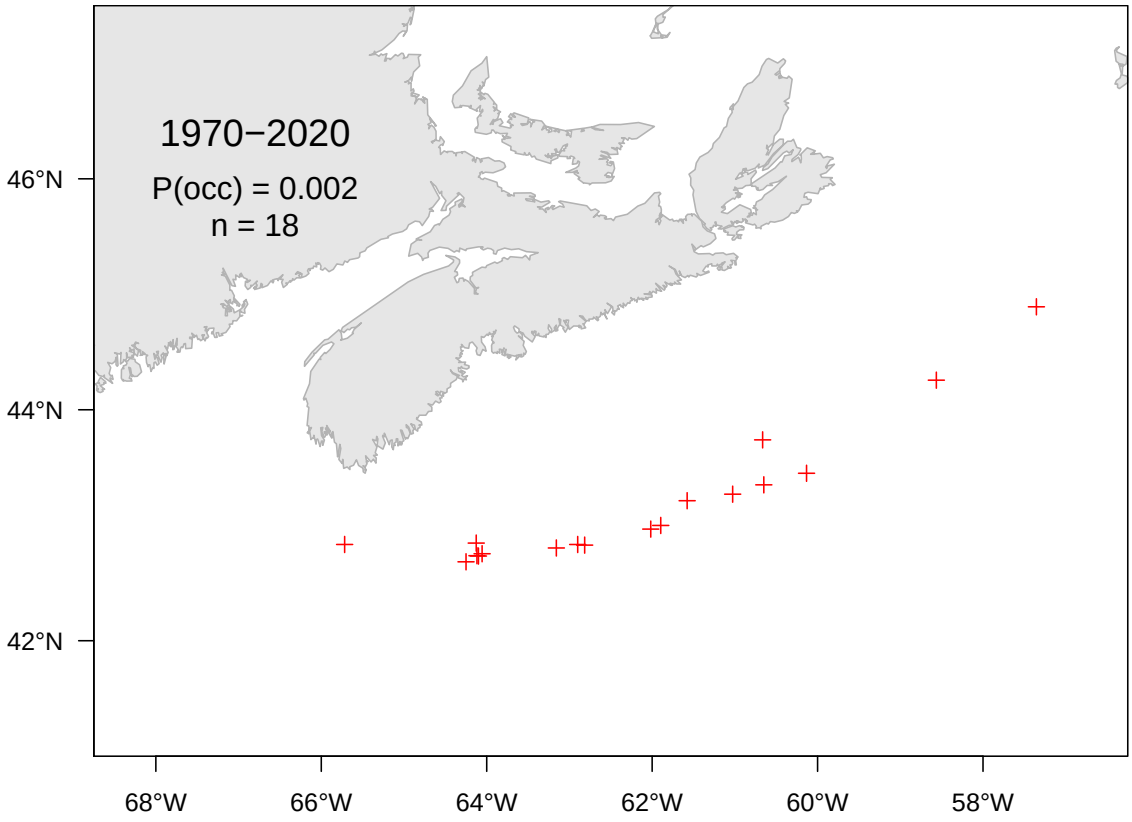


Figure 7.100A. Catch distribution for Atlantic batfish.

7.101 Spottedfin tonguefish (Langue fil noir) - species code 816 (category LR)

Scientific name: Symphurus diomedeanus

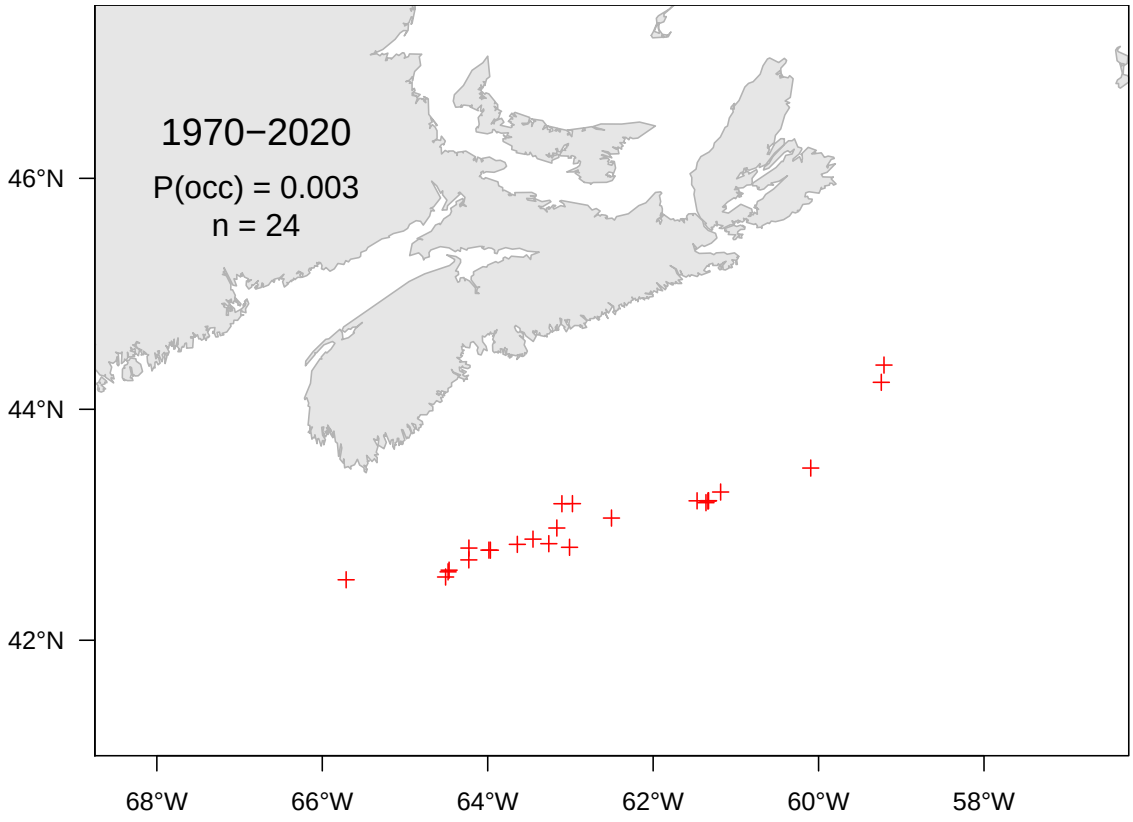


Figure 7.101A. Catch distribution for Spottedfin tonguefish.

7.102 Black dogfish (Aiguillat noir) - species code 221 (category LR)

Scientific name: Centroscyllium fabricii

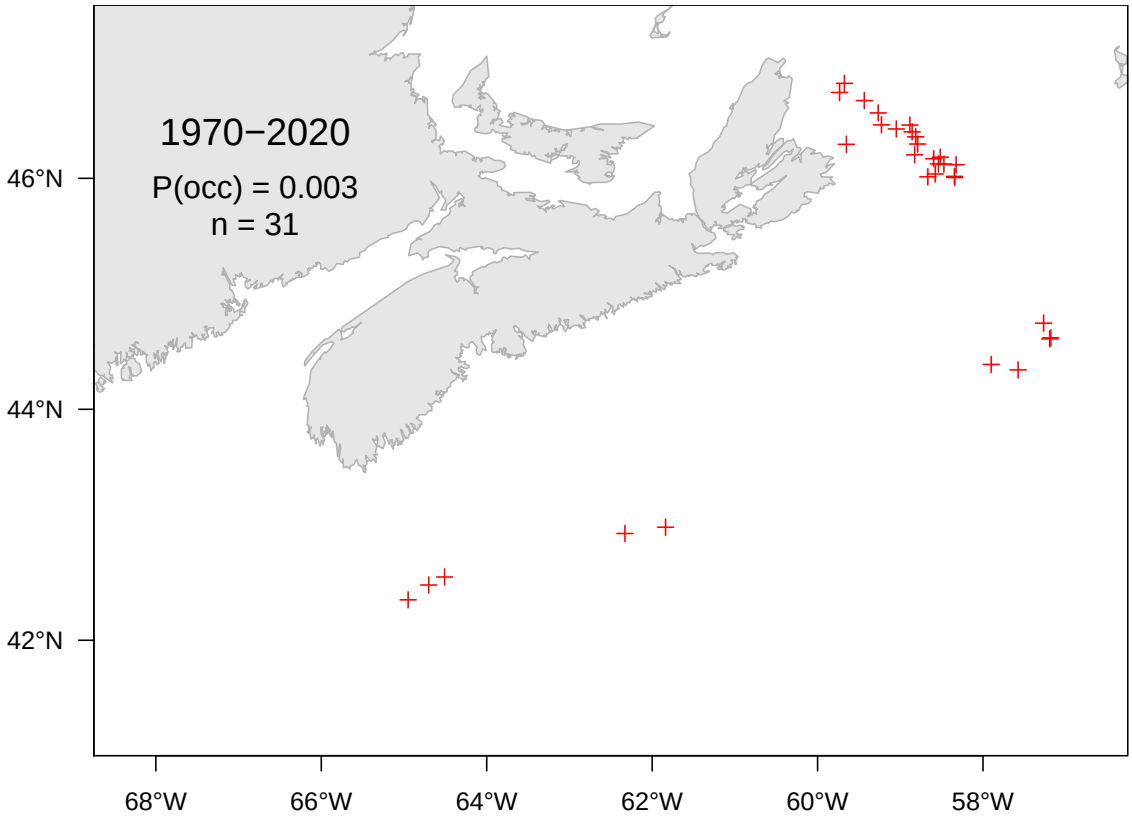


Figure 7.102A. Catch distribution for Black dogfish.

7.103 Longfin inshore squid (Calmar totam) - species code 4512 (category LR)

Scientific name: Doryteuthis pealeii

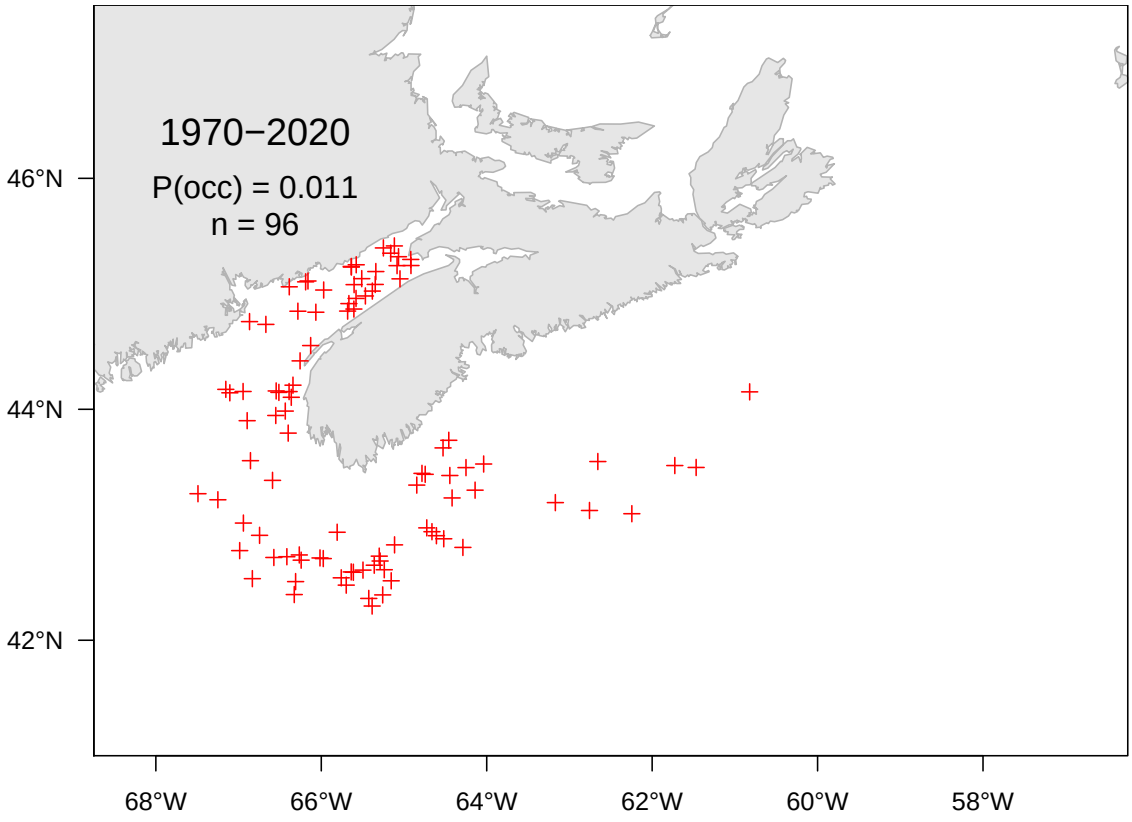


Figure 7.103A. Catch distribution for Longfin inshore squid.

7.104 Red deepsea crab (Crabe rouge) - species code 2532 (category SR)

Scientific name: Chaceon quinquedens

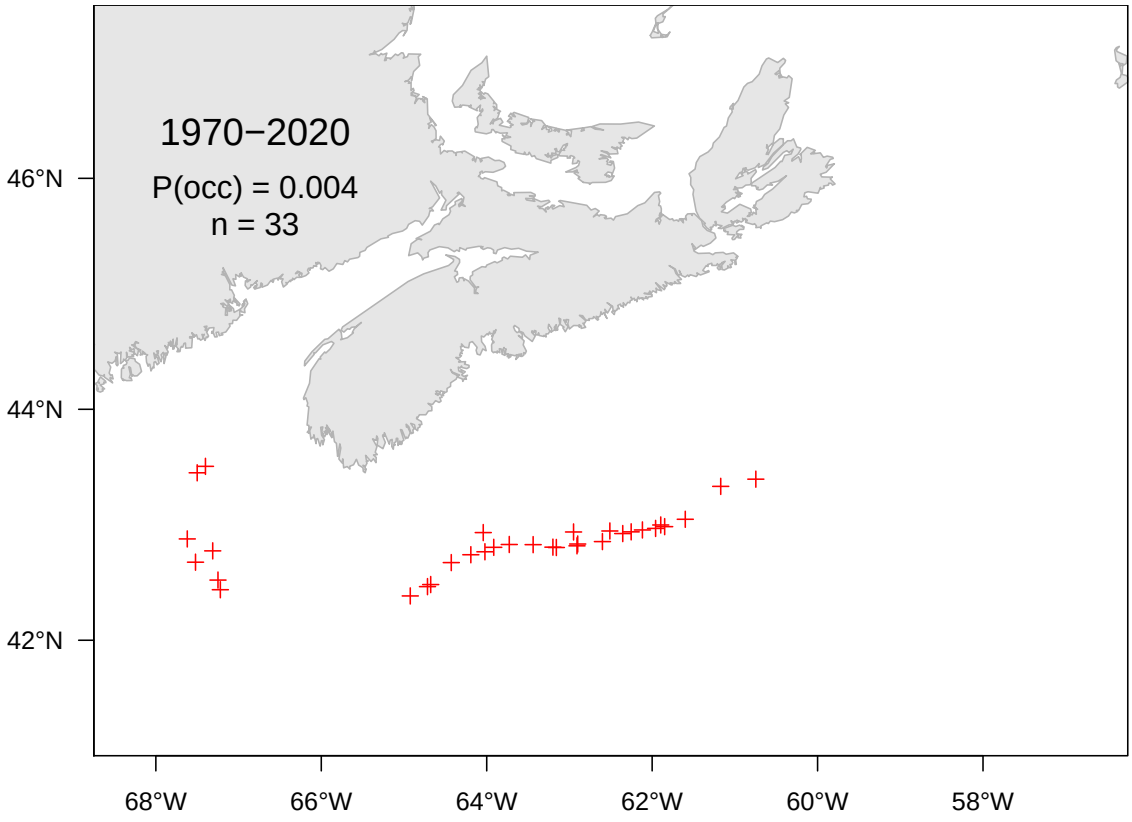


Figure 7.104A. Catch distribution for Red deepsea crab.

INDEX

Agone atlantique, 117
Agonidae, 156
    Agonidae, 156
    Aspidophoroides monopterygius, 80
    Leptagonus decagonus, 117
    Ulcina olrikii, 155
Aiglefin, 32
Aiguillat commun, 98
Aiguillat noir, 180
Alewife, 109
Alligatorfish, 80
Alligatorfishes, 156
Alosa pseudoharengus, 109
Alosa sapidissima, 108
Alose savoureuse, 108
Amblyraja radiata, 89
American lobster, 136
American plaice, 53
American shad, 108
Ammodytes dubius, 121
Ammodytidae
    Ammodytes dubius, 121
Anarhichadidae
    Anarhichas denticulatus, 141
    Anarhichas lupus, 65
    Anarhichas minor, 140
Anarhichas denticulatus, 141
Anarhichas lupus, 65
Anarhichas minor, 140
Arctic alligatorfish, 155
Arctic eelpout, 172
Arctic hookear sculpin, 116
Arctic lyre crab, 132
Arctozenus risso, 175
Argentina silus, 115
Argentinidae
    Argentina silus, 115
Artediellus atlanticus, 126
Artediellus uncinatus, 116
Aspidophoroides monopterygius, 80
Atlantic batfish, 178
Atlantic butterfish, 125
Atlantic cod, 29
Atlantic hagfish, 104
Atlantic halibut, 50
Atlantic herring, 68
Atlantic hookear sculpin, 126
Atlantic king crab, 133
Atlantic mackerel, 111
Atlantic poacher, 117
Atlantic redfishes, 47
Atlantic rock crab, 131
Atlantic saury, 176
Atlantic seasnail, 159
Atlantic soft pout, 173
Atlantic spiny lumpsucker, 120
Atlantic tomcod, 138
Atlantic wolffish, 65
Avocette ruban, 164

Balaou atlantique, 176
Barndoor skate, 127
Baudroie d'Amérique, 83
Black dogfish, 180
Blackbelly rosefish, 114
Boa dragonfish, 150
Brosme, 105
Brosme brosme, 105
Brossé améthyste, 149

Callionymidae
    Foetorepus agassizii, 171
Calmar totam, 181
Cancer borealis, 130
Cancer irroratus, 131
Cancridae
    Cancer borealis, 130
    Cancer irroratus, 131
Capelan, 110
Capelin, 110
Cardeau à quatre ocelles, 144
Careproctus reinhardti, 162
Centroscyllium fabricii, 180
Chaboisseau bronzé, 152
Chaboisseau à dix-huit épines, 71
Chaboisseau à épines courtes, 151
Chaceon quinquedens, 182
Chionoecetes opilio, 134
Chlorophthalmidae
    Chlorophthalmus agassizi, 148
    Parasudis truculenta, 146
Chlorophthalmus agassizi, 148

Citharichthys arctifrons, 107
Clupea harengus, 68
Clupeidae
    Alosa pseudoharengus, 109
    Alosa sapidissima, 108
    Clupea harengus, 68
Coryphaenoides rupestris, 158
Cotte polaire, 153
Cottidae
    Artediellus atlanticus, 126
    Artediellus uncinatus, 116
    Icelus spatula, 154
    Myoxocephalus aenaeus, 152
    Myoxocephalus octodecemspinosus, 71
    Myoxocephalus scorpius, 151
    Triglops murrayi, 74
Cottunculus microps, 153
Crabe des neiges, 134
Crabe Hyas coarctatus, 132
Crabe lyre araignée, 135
Crabe rouge, 182
Crabe épineux du nord, 133
Crevette nordique, 129
Cryptacanthodes maculatus, 170
Cryptacanthodidae
    Cryptacanthodes maculatus, 170
Cunner, 143
Cusk, 105
Cyclopteridae
    Cyclopterus lumpus, 119
    Eumicrotremus spinosus, 120
Cyclopterus lumpus, 119
Cynoglossidae
    Symphurus diomedeanus, 179

Daubed shanny, 123
Dibranchus atlanticus, 178
Dipturus laevis, 127
Doryteuthis pealeii, 181
Dragon-boa, 150
Dragonnet tacheté, 171

Enchelyopus cimbrius, 113
Encornet rouge nordique, 101
Etmopteridae
    Centroscyllium fabricii, 180
Eumesogrammus praecisus, 169
Eumicrotremus spinosus, 120
Faux-trigle armé, 74
Flétan de l'Atlantique, 50
Flétan noir, 106
Foetorepus agassizii, 171
Fourbeard rockling, 113
Fourline snakeblenny, 169
Fourspot flounder, 144

Gadidae
    Gadus morhua, 29
    Melanogrammus aeglefinus, 32
    Microgadus tomcod, 138
    Pollachius virens, 44
Gadus morhua, 29
Gaspareau, 109
Gelatinous snailfish, 160
Geryonidae
    Chaceon quinquedens, 182
Glyptocephalus cynoglossus, 56
Goberge, 44
Grande argentine, 115
Grande raie, 127
Great spider crab, 135
Greater argentine, 115
Greenland halibut, 106
Grenadier de roche, 158
Grenadier du Grand Banc, 118
Grenadier-scie, 157
Grubby, 152
Gulf Stream flounder, 107

Haches d'argent, 177
Haddock, 32
Hameçon atlantique, 126
Hameçon neigeux, 116
Hareng de l'Atlantique, 68
Hatchetfishes, 177
Helicolenus dactylopterus, 114
Hemitripteridae
    Hemitripterus americanus, 77
Hemitripterus americanus, 77
Hippoglossina oblonga, 144
Hippoglossoides platessoides, 53
Hippoglossus hippoglossus, 50
Homard américain, 136
Homarus americanus, 136
Hyas araneus, 135
Hyas coarctatus, 132

Hémitriptère atlantique, 77

Icelus spatula, 154
Icèle spatulée, 154
Illex illecebrosus, 101

Jonah crab, 130

Labridae
    Tautogolabrus adspersus, 143
Lamproie marine, 137
Langue fil noir, 179
Lanternfishes, 147
Lançon, 121
Leptagonus decagonus, 117
Leptoclinus maculatus, 123
Leucoraja erinacea, 128
Leucoraja ocellata, 95
Limace atlantique, 159
Limace gélatineuse, 160
Limace marbée, 161
Limanda ferruginea, 59
Limande à queue jaune, 59
Limande-plie rouge, 62
Liparidae
    Careproctus reinhardti, 162
    Liparis atlanticus, 159
    Liparis fabricii, 160
    Liparis gibbus, 161
Liparis atlanticus, 159
Liparis fabricii, 160
Liparis gibbus, 161
Lithodes maja, 133
Lithodidae
    Lithodes maja, 133
Little skate, 128
Loliginidae
    Doryteuthis pealeii, 181
Lompe, 119
Lompénie tachetée, 123
Lompénie-serpent, 122
Longfin hake, 112
Longfin inshore squid, 181
Longhorn sculpin, 71
Longnose greeneye, 146
Lophiidae
    Lophius americanus, 83
Lophius americanus, 83
Loquette d'Amérique, 86
Lotidae
    Brosme brosme, 105
    Enchelyopus cimbrius, 113
Loup atlantique, 65
Loup tacheté, 140
Loup à tête large, 141
Lumpenus lampretaeformis, 122
Lumpfish, 119
Lussion blanc, 175
Lycenchelys verrillii, 163
Lycode arctique, 172
Lycode du Labrador, 165, 166
Lycode à carreaux, 124
Lycode à tête longue, 163
Lycodes lavalaei, 166
Lycodes reticulatus, 172
Lycodes terraenovae, 165
Lycodes vahlii, 124

Macrouridae
    Coryphaenoides rupestris, 158
    Nezumia bairdii, 118
    Trachyrincus murrayi, 157
Malacoraja senta, 92
Mallotus villosus, 110
Malthe atlantique, 178
Maquereau commun, 111
Marlin-spike grenadier, 118
Maurolicus muelleri, 149
Melanogrammus aeglefinus, 32
Melanostigma atlanticum, 173
Merlu argenté, 41
Merlu argenté du large, 139
Merlucciidae
    Merluccius albidus, 139
    Merluccius bilinearis, 41
Merluccius albidus, 139
Merluccius bilinearis, 41
Merluche blanche, 35
Merluche à longues nageoires, 112
Merluche écureuil, 38
Microgadus tomcod, 138
Molasse atlantique, 173
Monkfish, 83
Morue franche, 29
Motelle à quatre barbillons, 113
Moustache sculpin, 74

Myctophidae, 147
    Myctophidae, 147
Myoxocephalus aenaeus, 152
Myoxocephalus octodecemspinosus, 71
Myoxocephalus scorpius, 151
Myxine du nord, 104
Myxine glutinosa, 104
Myxinidae
    Myxine glutinosa, 104

Nemichthyidae
    Nemichthys scolopaceus, 164
Nemichthys scolopaceus, 164
Nephropidae
    Homarus americanus, 136
Newfoundland eelpout, 165, 166
Nezumia bairdii, 118
Northern prawn, 129
Northern shortfin squid, 101
Northern wolffish, 141

Ocean pout, 86
Oeil-vert à long nez, 146
Offshore silver hake, 139
Ogcocephalidae
    Dibranchus atlanticus, 178
Ommastrephidae
    Illex illecebrosus, 101
Oregoniidae
    Chionoecetes opilio, 134
    Hyas araneus, 135
    Hyas coarctatus, 132
Osmeridae
    Mallotus villosus, 110
    Osmerus mordax, 142
Osmerus mordax, 142

Pandalidae
    Pandalus borealis, 129
Pandalus borealis, 129
Paralepididae
    Arctozenus risso, 175
Paralichthyidae
    Citharichthys arctifrons, 107
    Hippoglossina oblonga, 144
Parasudis truculenta, 146
Peprilus triacanthus, 125
Petite limace de mer, 162
Petite poule de mer atlantique, 120
Petromyzon marinus, 137
Petromyzontidae
    Petromyzon marinus, 137
Pholidae
    Pholis gunnellus, 167
Pholis gunnellus, 167
Phycidae
    Phycis chesteri, 112
    Urophycis chuss, 38
    Urophycis tenuis, 35
Phycis chesteri, 112
Picked dogfish, 98
Pleuronectidae
    Glyptocephalus cynoglossus, 56
    Hippoglossoides platessoides, 53
    Hippoglossus hippoglossus, 50
    Limanda ferruginea, 59
    Pseudopleuronectes americanus, 62
    Reinhardtius hippoglossoides, 106
Plie canadienne, 53
Plie du Gulf Stream, 107
Plie grise, 56
Poisson-alligator arctique, 155
Poisson-alligator atlantique, 80
Poissons-alligator, 156
Poissons-lanternes, 147
Polar sculpin, 153
Pollachius virens, 44
Pollock, 44
Poulamon atlantique, 138
Pseudopleuronectes americanus, 62
Psychrolutidae
    Cottunculus microps, 153

Quatre-lignes atlantique, 169
Queen crab, 134

Radiated shanny, 168
Raie hérisson, 128
Raie lisse, 92
Raie tachetée, 95
Raie épineuse, 89
Rainbow smelt, 142
Rajidae
    Amblyraja radiata, 89
    Dipturus laevis, 127
    Leucoraja erinacea, 128

Leucoraja ocellata, 95
Malacoraja senta, 92
Red deepsea crab, 182
Red hake, 38
Reinhardtius hippoglossoides, 106
Rock gunnel, 167
Roughnose grenadier, 157
Roundnose grenadier, 158

Saint Pierre argenté, 174
Sand lance, 121
Scomber scombrus, 111
Scomberesocidae
Scomberesox saurus, 176
Scomberesox saurus, 176
Scombridae
Scomber scombrus, 111
Scophthalmidae
Scophthalmus aquosus, 145
Scophthalmus aquosus, 145
Sea lamprey, 137
Sea raven, 77
Sea tadpole, 162
Sebastes, 47
Sebastidae
Helicolenus dactylopterus, 114
Sebastes, 47
Shorthorn sculpin, 151
Shortnose greeneye, 148
Sigouine de roche, 167
Silver hake, 41
Silvery John dory, 174
Silvery lightfish, 149
Slender snipe eel, 164
Smooth skate, 92
Snakeblenny, 122
Spatulate sculpin, 154
Spotfin dragonet, 171
Spotted wolffish, 140
Spottedfin tonguefish, 179
Squalidae
Squalus acanthias, 98
Squalus acanthias, 98
Sternoptychidae, 177
Maurolicus muelleri, 149
Sternoptychidae, 177
Stichaeidae
Eumesogrammus praecisus, 169
Leptoclinus maculatus, 123
Lumpenus lampretaeformis, 122
Ulvaria subbifurcata, 168
Stomias boa, 150
Stomiidae
Stomias boa, 150
Stromateidae
Peprilus triacanthus, 125
Stromaté fossette, 125
Symphurus diomedeanus, 179
Sébaste chèvre, 114
Sébastes de l'Atlantique, 47

Tanche-tautogue, 143
Tautogolabrus adspersus, 143
Terrassier tacheté, 170
Thorny skate, 89
Tourteau jona, 130
Tourteau poïnclos, 131
Trachyrincus murrayi, 157
Triglops murrayi, 74
Turbot de sable, 145

Ulcina olrikii, 155
Ulvaire deux-lignes, 168
Ulvaria subbifurcata, 168
Urophycis chuss, 38
Urophycis tenuis, 35

Vahl's eelpout, 124
Variegated snailfish, 161

White barracudina, 175
White hake, 35
Windowpane flounder, 145
Winter flounder, 62
Winter skate, 95
Witch flounder, 56
Wolf eelpout, 163
Wrymouth, 170

Yellowtail flounder, 59

Zeidae
Zenopsis conchifer, 174
Zenopsis conchifer, 174
Zoarces americanus, 86
Zoarcidae
Lycenchelys verrillii, 163

Lycodes lavalaei, 166
Lycodes reticulatus, 172
Lycodes terraenovae, 165
Lycodes vahlii, 124
Melanostigma atlanticum, 173
Zoarces americanus, 86
Éperlan arc-en-ciel, 142
Éperlan du large, 148